DISSERTATIONS

RELATIVE TO THE

NATURAL HISTORY

OF

ANIMALS AND VEGETABLES.

TRANSLATED FROM THE ITALIAN OF THE

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INTRODUCTION.

IN the courſe of my public demonſtrations in the year 1777, I repeated in the preſence of my hearers thoſe celebrated experiments of the Academy of Cimento, which ſhew that the ſtomachs of fowls and ducks exert ſo aſtoniſhing a force as to reduce hollow globules of glaſs to powder in the ſpace of a few hours. Finding them perfectly exact, I conceived the deſign of extending them to ſome other individuals of that claſs of birds which have been termed birds with *muſcular ſtomachs* or *gizzards*. Such were the firſt lines of an undertaking, of which till that time I had never entertained the ſmalleſt idea, and which afterwards became more and more extenſive, as my curioſity concerning ſo fine and uſeful a ſubject as the important function of Digeſtion increaſed. Hence from animals with muſcular ſtomachs, I was induced to proceed to thoſe with intermediate, and from theſe again to animals with membranous ſto-

machs (*a*). Thus I enjoyed the pleaſure of extending my reſearches to the principal claſſes of animals, not neglecting Man, the nobleſt and moſt intereſting of all. But theſe phyſiological reſearches laid me under the neceſſity of examining the moſt celebrated ſyſtems concerning Digeſtion, and of enquiring whether it is effected by trituration, by a ſolvent, by fermentation, or by an incipient putrefaction: or whether, according to the opinion of the great Boerhaave, it rather depends upon all theſe cauſes operating in conjunction. Thus I was obliged to enter anew upon a queſtion of very ancient date, and though diſcuſſed at great length by many phyſiologiſts, yet not in my opinion ſufficiently elucidated; ſince moſt writers have choſen to follow the deluſive invitation of theory and hypotheſis, rather than the unerring direction of deciſive experiments. The impartial and judicious reader, when he ſhall have peruſed the preſent eſſay, will be able to determine, whether what I aſſert, be true or falſe.

(*a*) The I, LVIII, and CIV paragraphs will explain what is meant by birds with muſcular, intermediate, and membranous ſtomachs.

DISSERTATION I.

CONCERNING

DIGESTION.

ON THE DIGESTION OF ANIMALS WITH MUSCULAR STOMACHS, COMMON FOWLS, TURKEYS, DUCKS, GEESE, DOVES, PIGEONS.

I. THOUGH there perhaps exiſts no animal, of which the ſtomach is not furniſhed with muſcles, yet there is a ſingular claſs, juſtly denominated by ſeveral naturaliſts *animals with muſcular ſtomachs*, ſince that viſcus is provided with remarkably large and powerful muſcles. To this claſs belong fowls, ducks, pigeons, geeſe, partridges, &c. So great is the ſtrength of theſe muſcles, that many have imagined that they produce digeſtion by acting violently upon the contents of the ſtomach, and breaking down and re-

ducing them to a pultaceous maſs, in no reſpect differing from imperfect chyle. This notion was afterwards applied to other animals, nor was man himſelf exempted; and it has been pretended, that digeſtion is univerſally owing to the alternate action of the muſcles of the ſtomach, or, as it has been termed, to *trituration*.

II. Now, to confine ourſelves to animals with muſcular ſtomachs, there was little difficulty in deviſing the means of determining whether the comminution and ſolution of food is effected by the gaſtric muſcles. Such means have been contrived and ſucceſsfully put in practice by Reaumur. "Let ſeveral animals reſembling each other in ſtructure," ſays that great naturaliſt in his two excellent memoirs on this ſubject, of which I ſhall make frequent uſe in the ſequel, "be made to ſwallow metallic tubes open at both ends, and filled with ſome of their natural food, as grains of the *Cerealia* when gallinaceous fowls are the ſubjects of our experiments. Should theſe grains, after they have remained a certain time in the ſtomach, be broken down and decompoſed, we muſt aſſume a diſſolving liquor as the cauſe of this phænomenon, ſince the ſides of the metallic tubes muſt have been an inſuperable obſtacle to the exertions of the gaſtric

gaſtric muſcles upon the contents; but if they ſhould be retrieved in a ſound and entire ſtate, it muſt be acknowledged, that in theſe animals digeſtion does not depend on a ſolvent, but on the action of muſcles." And ſuch was the plan adopted by this ſagacious philoſopher. He encloſed ſome barley in metallic tubes open at each end and forced them down the throats of common fowls, turkeys and ducks. Upon killing the animals ſome hours afterwards and taking the tubes out of the ſtomach, the grains were found quite entire; whence he inferred, that in birds of the gallinaceous claſs the food is not broken down by a ſolvent, but by ſtrong muſcular action.

III. This experiment ſeems indeed highly favourable to the doctrine of trituration; yet I think it would have been much more concluſive, if the ſame reſult had been obtained from other individuals of this claſs, and if beſides barley, other grains upon which they naturally feed, ſuch as wheat, maize, rye, chickpeaſe, &c. had been employed. I therefore reſolved to put each of theſe ſeeds to the teſt of experiment in the following manner. I procured ſome tin tubes eight lines in length and four in diameter, and incloſed in each a quantity of ſeeds greater or leſs according as

they were themselves smaller or larger. The ends of the tube were left open, but iron wires were made to pass before them, so as to cross each other, and form a kind of lattice-work. Common fowls were the first subjects of my experiments: I forced some of the tubes into the stomach, conducting them with my fore-finger and thumb through the œsophagus, till I was certain they were in the cavity of that viscus. When this operation is properly performed, neither fowls nor other animals sustain any injury. In twenty-four hours the tubes were taken out, and the contents upon examination appeared to be unaltered; even the colour and taste were unchanged, if we except a slight bitter flavour which they had acquired. They had imbibed some moisture, and were a little swoln. The same seeds inclosed also in tubes, and left in the stomach two and even three days, underwent no greater change.

IV. Several times, immediately after having forced the tubes full of grains into the stomach, I introduced some of the same grains loose. The latter were broken down in a few hours, but the former remained entire.

V. The food taken spontaneously by these birds does not pass immediately into the stomach, but stops for some time in the crop, where

where it is macerated, and becomes ſofter. Is ſuch a previous maceration neceſſary before it can be diſſolved within the tubes? This circumſtance ſeemed to deſerve attention. I therefore repeated the foregoing experiments with ſeeds taken from the crop of a fowl, after they had undergone a complete maceration. Notwithſtanding this preparation, they underwent no change within the tubes.

VI. From theſe reſults it was eaſy to predict, that no new appearance would occur, if the ſkin ſhould be taken off, as it really happened. It is proper to add, that other grains treated in the ſame manner were no more diſſolved than thoſe before-mentioned.

VII. The mode which I had hitherto practiſed of uſing tubes open at both ends, at which the gaſtric fluid was certainly at liberty to enter, was that of Reaumur. But this fluid having no other acceſs, cannot exert its action on the incloſed grains ſo powerfully as when they are looſe in the ſtomach, as Reaumur ingenuouſly confeſſes. To obviate this inconvenience in ſome meaſure, I had the ſides of the tubes perforated with a great number of holes. I had moreover recourſe to another expedient. I employed hollow globules of braſs half an inch in diameter, and pierced like a ſieve, which I could open and

ſhut at pleaſure by means of a ſcrew worked upon the edge of the two hemiſpheres, into which each globule was diviſible. With theſe new tubes and ſpherules I repeated the preceding experiments, not only upon common fowls, but upon ducks, turkeys, geeſe, doves, and pigeons: and as a larger quantity of liquor could now find its way to the incloſed ſubſtances, they were more thoroughly ſoaked, and had acquired a bitterer taſte (III); but I could never perceive the ſlighteſt token of ſolution, though they continued a long time in the ſtomach.

VIII. Theſe facts afford an irrefragable proof, that the trituration of ſeeds in the ſtomach of granivorous birds, is ſolely owing to ſtrong preſſure and repeated and violent percuſſions: effects produced by the powerful muſcles with which that organ is furniſhed.

IX. The contents of the ſtomach are ſo violently agitated as to be driven in at the open ends and through the holes of the tubes and ſpherules, which occaſions ſome confuſion. Hence I have frequently found it of ſervice to introduce theſe receivers when the ſtomach was empty, and to keep the animal faſting during the whole time of the experiment.

X. The

x. The violent action of the ſides upon the contents of the ſtomach renders another precaution highly neceſſary. The thickneſs of the tubes and ſpherules ſhould be conſiderable, otherwiſe the obſerver, when he takes them out of the ſtomach, will find them broken, cruſhed, or diſtorted in a moſt ſingular manner, if they have been long retained. Reaumur mentions ſeveral accidents of this ſort (*a*); and I have ſeen inſtances without number of ſuch contuſions, one of which I cannot forbear relating here. Having found that the tin tubes which I uſed for common fowls were incapable of reſiſting the force of the ſtomach of turkeys, and not happening at that time to be provided with any tin foil of greater thickneſs, I tried to ſtrengthen them by ſoldering to the ends two circular plates of the ſame metal, perforated only with a few holes for the admiſſion of the gaſtric fluid. But this contrivance was ineffectual; for after the tubes had been twenty hours in the ſtomach of a turkey, the circular plates were driven in, and ſome of the tubes were broken, ſome compreſſed, and ſome diſtorted in the moſt irregular manner.

(*a*) In the Memoir quoted above.

XI. I then tried the following means of preventing this inconvenience. Having perforated the circular laminæ in the center, I paſſed an iron wire through the holes, and bound it tight round the outſide of the tubes and twiſted the two ends together. And now though the ſoldering ſhould be deſtroyed, yet this contrivance would prevent the circular laminæ from receding from the ends of the tube, unleſs the wire which paſſed through them ſhould be broken. I prepared four tubes in this manner, and gave them to a turkey ſix months old. After they had remained a whole day in the ſtomach, I killed the animal; and was exceedingly ſurprized to find that the tubes, in ſpite of my expedient, were very much damaged. All the iron wires were broken, two where they were twiſted, and the two others at their entrance into the tubes; the laminæ, ſo far from remaining ſoldered to the tubes, were found amongſt the food; they were not flat as at firſt, but ſome were bent ſo as to form an angle, ſome curved, and in others, one part was preſſed cloſe to the other. The tubes had ſuſtained equal injury; two of them were flattened as if they had been ſtruck by an hammer, the third was moulded into the ſhape of a gutter, the ſoldering of the fourth was deſtroyed, and it was made as flat as a wafer.

XII. Theſe

XII. These phænomena will not so much surprize those who have learned from Redi (*a*) and Magalotti (*b*), how ducks, fowls, and pigeons reduce to powder hollow globules of glass in a very short space of time, and even solid ones in a few weeks. I have already observed, that I repeated these experiments with the greatest success (*c*). Some spherules of glass blown by the lamp, and so thick that they would seldom break when thrown upon the ground, were commonly reduced to small fragments, after remaining three hours in the stomach of a hen or a capon; the fragments were not sharp as when they are broken by the efforts of the hand, but as obtuse as if their edges and points had been abraded by a grinding-stone. The longer the spherules continued in the stomach, the more minutely were they triturated; so that in a few hours they were reduced to a mass of particles, not larger than grains of sand. Moreover the rapidity of this process appears in some measure proportional to the size of the animal. A wood-pigeon generally breaks them less speedily than a chicken, a chicken than a

(*a*) Esperienze intorno a cose naturali.
(*b*) Saggio di naturali esperienze.
(*c*) In the Introduction.

capon,

capon, but a goose the soonest of all. The reason is plain, since the larger species have thicker and more powerful stomachs.

XIII. From these and other facts which I shall adduce hereafter, we may collect how much the celebrated Pozzi, formerly Professor at Bologna, was mistaken, when he considered the observations (*a*) of the Florentine Academicians, and of Redi on the power of certain animals to reduce globules of glass to pieces as false, because he failed in his attempts to repeat their experiments on pigeons. Let me here be allowed to remark that it is the custom of certain dabblers in philosophy to deny facts, however particularly described, and though related by persons of the highest authority, merely because their own endeavours fail of success. But they do not reflect, that this is acting in direct opposition to the principles of sound logic, by which we are taught that a thousand negative facts cannot destroy a single positive fact, since it is so very easy to omit some one or other of the many circumstances requisite to the success of an experiment. The Bolognian Physician has fallen into this error; instead of so rashly inferring from his own observation the falsity of the

(*a*) In his short anatomical essay printed at Bologna by Lælius a Vulpe.

contrary

contrary event, he ought to have multiplied and varied his experiments; and if he had done this with proper precautions, he would have confirmed, inſtead of contradicting the relation of the Florentine philoſophers. We muſt ſuppoſe, that the ſtomachs of his pigeons were too weak and flaccid to abrade and break ſubſtances of ſuch hardneſs as glaſs, from their being either in an unhealthy ſtate, or too young; for in theſe caſes they are by no means capable of producing ſuch effects, as I have found from actual experience.

XIV. My celebrated countryman Vallisneri, in his judicious *anatomy of the oſtrich*, ſuppoſes that the hardeſt ſubſtances, ſuch as ſtones, wood, glaſs, and even iron itſelf, are reduced to pieces in the ſtomach of this enormous bird by a ſolvent; he alſo inclines to think, that glaſs is attacked and broken by ſuch a liquor, which he imagines to exiſt in the ſtomachs of fowls, without the concurrence of muſcular action. But the hypotheſis of Vallisneri is evidently groundleſs; for ſeeds, as we have ſeen above, remain unaltered whenever they are defended by tubes. And when pigeons, fowls, or turkeys, are forced to ſwallow ſeveral balls of glaſs at once, ſome incloſed in tubes, and others looſe, the latter are reduced to ſmall fragments as uſual, while

while the former remain entire. That the gastric muscles are the sole cause of this effect, will appear still more evidently from facts to be related in the sequel (xv).

xv. Before I proceed farther in the recital of experiments immediately relating to digestion, it may be proper to mention some other phænomena analogous to those just described. They may help to convey more distinct notions concerning this function in animals furnished with gizzards; the smooth and blunt substances hitherto employed, could not injure the stomach. It was therefore an object of curiosity to enquire what would happen when sharp bodies were introduced. It is well known how readily broken glass will lacerate flesh. I therefore gave a cock several fragments of a broken pane, each about the size of a pea; they were wrapped up in paper, to prevent the œsophagus from being torn as they passed through it. I was well assured that this cover would be immediately destroyed on its entrance into the stomach, and leave the glass at liberty to act with its points and edges. The animal was killed in twenty-four hours, and the glass was found in the stomach; but on this, as well as former occasions, the angles were so far obliterated, that upon putting some of the fragments on the

the palm of one hand, and rubbing them forcibly on the back of the other, I did not receive the leaſt hurt. Upon weighing the glaſs, it appeared to have loſt twenty-four grains; nor was it difficult to diſcover what was become of the miſſing particles, for the ſides of the ſtomach, when viewed attentively glittered with innumerable vitreous points. On the contrary, ſome broken bits of glaſs, that were incloſed in two tubes, of which one was given to a hen, and the other to a turkey, and left twenty-four hours in the ſtomach, were not at all abraded at their points or edges.

XVI. Similar pieces of glaſs, that remained two days in the ſtomach of a wood-pigeon, gave me an opportunity of obſerving other remarkable fractures and abraſions. The mention of this bird brings to my mind a fact relating to the preſent ſubject. I gave a wood-pigeon an unpoliſhed twelve-ſided garnet, of the ſize of a nut, with the intention of inſpecting the ſtomach a few hours afterwards; the bird was confined in a cage, but made its eſcape by ſome accident, and mixing among a number of others kept in another place, I was not able to diſtinguiſh it; ſo that it did not fall into my hands for a month. The garnet, which had remained all this time in

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the ſtomach, filled almoſt its whole capacity; a circumſtance which a little ſurprized me, ſince it had taken its food, and been nouriſhed very well. But I was ſtill more ſurprized at finding the angles of this hard ſtone blunted in ſome places.

XVII. But the reader will ſurely be eager to learn what injury the ſtomach received from the violent agitation thoſe ſharp bodies muſt have undergone during the abraſion of their moſt pointed parts. To ſatisfy my own curioſity, as well as that of others, I opened the cock and the two wood-pigeons (XV, XVI), and examined the internal coat of the ſtomach with the cloſeſt attention, after having waſhed away the contents. I moreover diſſected it away from the nervous coat; this was eaſily effected: and I could now examine it to greater advantage, but notwithſtanding all my pains, found it perfectly entire. No laceration, no diviſion, not the ſmalleſt jagged appearance; it was in every reſpect like ſtomachs that had not afforded reception to any unuſual ſubſtance. Only the coat of that ſtomach which had retained the large garnet for a month, was about three times as thick as it commonly is.

XVIII. Finding that theſe fowls ſuſtained theſe experiments unhurt, I ſubjected them

to two others far more dangerous. Twelve ſtrong needles were firmly fixed in a ball of lead, in ſuch a manner that the points projected about a quarter of an inch from the ſurface. Thus armed, it was covered with a caſe of paper, and forced down the throat of a turkey. The bird retained it for a day and half without ſhewing the leaſt ſymptom of uneaſineſs. Why the ſtomach ſhould have received no injury from ſo horrid an inſtrument, I cannot explain: but the points of the twelve needles were broken off cloſe to the ſurface of the ball, except two or three of which the ſtumps projected a little higher. The ball had not loſt its general ſhape, but was marked with ſeveral indentations, that certainly were not upon it at firſt. Two of the points of the needles were found among the food, the other ten I could not diſcover either in the ſtomach or the long tract of the inteſtines; and therefore concluded that they had paſſed out at the vent.

XIX. The ſecond experiment, ſtill more cruel, conſiſted in fixing twelve ſmall lancets, with very ſharp points and edges, in a ſimilar ball of lead. They were ſuch as I uſe for the diſſection of ſmall animals. The ball was given to a turkey cock, and left eighteen hours in the ſtomach; at the expi-

ration of which time it was opened, but nothing appeared but the naked ball, the twelve lancets having been broken to pieces; I discovered three in the large inteſtines, pointleſs and mixed with the excrements; the other nine were miſſing, and had probably been voided at the vent. The ſtomach was as ſound and entire as that which had received the needles.

XX. Of two capons, one ſuſtained the experiment with the needles, and the other that with the lancets, equally well. My next wiſh was to know how much time had elapſed before thoſe ſubſtances begin to be acted upon. By repeated experiments on turkeys that were killed after intervals ſucceſſively ſhorter, I found that theſe ſharp bodies begin to be broken and loſe their ſhape in about two hours. This at leaſt happened in two individuals of that ſpecies: in one four of the lancets, and in the other, three of the needles were broken within that ſpace; the reſt were blunted, but continued firm in the balls.

XXI. Let it not however be ſuppoſed, that the ſtomach in this claſs of birds is altogether invulnerable. In pullets it certainly is ſometimes very much injured. I obliged two pullets to ſwallow ſome pins without heads. One was killed in eight, and the other in thirty-

thirty-two hours. The former had not at all ſuffered, but two pins were ſtuck in the ſtomach of the latter. Theſe ſtomachs, as well as thoſe of many other animals, are full of furrows, in one of which the two pins were fixed almoſt perpendicularly, one to the depth of a line, and the other to that of three lines: they were oppoſite to the moſt muſcular part of the organ. Some force was required to extract them; at the puncture appeared a little clotted blood, with an evident livid colour around.

XXII. But whatever concluſion we are to draw from this laſt fact, it is certain, that the ſtomach of ſuch birds is in general not ſubject to any injury from the introduction, reſidence, and trituration of theſe and the like ſubſtances, as I have learned from a vaſt variety of experiments. But how is it poſſible, ſome will enquire, that the gaſtric muſcles can contuſe, triturate, and even ſometimes reduce to impalpable powder (as when glaſs is employed, XII, XIV, XV, XVI) theſe pointed bodies without injury to themſelves? If the muſcles act with ſo much force, muſt not the ſubſtances neceſſarily re-act upon the muſcles? And will not this re-action cauſe the laceration of the internal coat of the ſtomach, which, though it is indeed very firm and compact, cannot ſurely ſuſtain ſuch violent ſhocks with impunity?

XXIII. This objection was immediately started, upon the discovery of the wonderful force with which digestion in poultry is effected, and an attempt was made to remove it in the following ingenious manner. It had been long known, that fowls, and other birds of the same class, have always a smaller or larger supply of little pebbles in their stomachs. It was therefore conceived, that these pebbles serve as a shield to the muscles. Hence it follows, that the comminution of bodies forced into the stomach is the immediate effect of the pebbles, and only the mediate effect of muscular action. Accordingly, the Academicians of Cimento have observed, that those ducks and fowls that have most stones in their stomachs, soonest reduce spherules of glass to powder. Redi thinks, that the stones perform the office of teeth (*a*); and Reaumur supposes them necessary to digestion (*b*).

XXIV. In the course of my numerous observations I can safely assert, that I never opened the stomach of a pigeon, turtle-dove, dove, partridge, fowl, turkey, goose, &c. without finding some small stones in it. I have also found what is remarked by Reaumur, that the size of the stones is apparently proportional to the size of the bird. They are generally of a roundish shape, whether

(*a*) L. c. (*b*) Mem. cit.

they

they acquire it from friction within the cavity of the ſtomach, or have it before they are ſwallowed. They are commonly bits of quartz, ſometimes mixed with fragments of calcareous ſtones. In the ſtomach of a turkey hen I have counted above 200, and above 1000 in that of a gooſe. Their exiſtence is therefore indubitable. But is it equally certain, that they are the immediate inſtruments of trituration? He who is unprejudiced in favour of any theory muſt immediately perceive, that this is a mere hypotheſis, convenient indeed and plauſible, but requiring to be confirmed by experiment.

XXV. To this teſt I have endeavoured to bring it, and would willingly hope that I have decided the queſtion. According to the obſervation of the Academicians, thoſe birds that have moſt ſtones in the ſtomach, ſooneſt triturate hard ſubſtances. Nothing was more eaſy than to repeat the experiment. This I did upon ducks and fowls, the two ſpecies mentioned by thoſe learned writers, ſometimes obliging them to ſwallow globules of glaſs, ſometimes thin tubes of tin, and at others ſeeds defended by a ſtronger cover, ſuch as nuts of a moderate ſize. It was neceſſary that all circumſtances ſhould be alike, that the birds ſhould be of the ſame ſpecies and age,

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and of equal vigour, &c. Not to weary the reader with too minute a detail, I ſhall only mention the reſults. In a hen and two ducks, not abundantly ſupplied with pebbles, the injury ſuſtained by the ſubſtances was not ſo great as in three other like fowls more amply provided with them. But in four hens the effect produced was exactly the ſame, as far as I could judge, though the ſtomachs of three were leſs copiouſly furniſhed than that of the fourth.

XXVI. Having collected a large quantity of ſtones from the diſſection of many gizzards, I thought they might be uſeful in the preſent inquiry; I therefore gave a certain number to ſome fowls and ducks, while others were left with thoſe which they had ſwallowed ſpontaneouſly. The former, according to the obſervation of the Florentine Academicians, ought to have broken down hard ſubſtances ſooner than the latter. And ſo indeed it ſometimes happened, but at others the event was different. Wherefore not being able to aſcertain the object of my enquiry by theſe experiments, I had recourſe to other means of ſolving the problem.

XXVII. The moſt deciſive mode of determining the uſe of ſtones in digeſtion, evidently was to take them away altogether,

either

either by expelling thoſe already ſwallowed, or by preventing the admiſſion of any at all. To evacuate thoſe already accumulated, it was neceſſary to confine the birds in cages where they could not find freſh ones, and it might be hoped, that the old ones would be gradually voided with the excrements. Accordingly, ſeveral fowls, turkeys, pigeons, and ducks were confined ſeparately, and that all ſuſpicion of their picking up pebbles might be removed, the cages were raiſed to ſuch an height that they could not reach the floor with their beaks. The bottoms were made of oſiers placed at a diſtance from each other, in order that if the ſtones ſhould paſs out with the excrement they might not remain in the cage, and be ſwallowed again, but fall to the ground. I fed them myſelf the whole time, taking care that the food, conſiſting of corn, vetches, and maize, ſhould be free from all foreign matter, ſo that I was certain not a ſingle grain of ſand or the ſmalleſt ſtone was ſwallowed by them.

XXVIII. In the courſe of a few days I perceived ſome ſtones among the excrement, and they continued to be voided during the whole time of confinement. Two days before the end of the month, when they were to be killed, I forced ſome to ſwallow tubes

of tin, others glaſs globules, others balls of lead, ſome naked and ſome armed with needles and lancets (XVIII, XIX, XX.) I likewiſe gave them ſome grains of wheat, but did not allow them to undergo the natural proceſs of maceration in the crop. On the 30th day every ſtomach was carefully examined, and though I did not completely attain the end in view, yet I gained conſiderable information on the ſubject. Not a ſingle ſtomach indeed was free from ſtones, but they were few in number, in ſome inſtances not amounting to above four or five, and thoſe very ſmall. The contuſions, however, on the tin tubes, the indentations on the naked balls, the fracture of the needles and lancets, the trituration of the grain had alike taken place in every ſtomach; nor did it appear, that the diminution of the quantity of ſtones at all contributed to diminiſh the alteration of the ſeveral ſubſtances, or to occaſion any injury to the organ that contained them. And leſt it ſhould be objected, that theſe hard bodies themſelves performed the office of pebbles by rubbing violently againſt each other in conſequence of the action of the gaſtric muſcles (an objection manifeſtly trivial) I had taken care that each bird ſhould not have more than one tin tube, or one glaſs globule,

&c.

&c. These solitary substances were just as much bruised or broken as when many were put into one stomach; and that viscus remained as free from injury.

XXIX. Though these facts abundantly prove, that trituration does not depend on the stones swallowed by the birds in question, but upon the strength and action of the gastric muscles, I yet wished, by observing what happens in stomachs that have not received any stones, for proofs still more decisive. The judicious reader will perceive at once, that to accomplish my purpose, it was necessary to procure young nestlings that had never been abroad in quest of food. Accordingly, I procured some wood-pigeons, yet unfledged, were brought me; but I was disappointed in my expectations, for even their tender stomachs were not free from pebbles, which doubtless were mixed with the food carried to them by their parents. Three of these young birds were sacrificed to my curiosity. The stomach of the first contained eight stones, of the second eleven, of the third fifteen; together they weighed thirty-two grains, and consisted chiefly of quartz.

XXX. As these experiments did not answer my purpose, it was necessary to take up the enquiry at an earlier period, and make use of

still

ſtill younger neſtlings; nay, for greater certainty ſuch as were juſt quitting the egg, and therefore could not have received food from their parents. The ſtomach, it is obvious, could not contain ſtones of any kind. I was therefore at the pains of keeping ſeveral neſtlings in a warm place, while they remained unfledged, and feeding them till they were able to peck. They were then confined in a cage, and ſupplied at firſt with vetches ſoaked in warm water, and afterwards in a dry and hard ſtate. In a month after they had begun to peck, hard bodies, ſuch as tin tubes, glaſs globules, and fragments of broken glaſs were introduced with the food; care was taken that each wood-pigeon ſhould ſwallow only one of theſe ſubſtances. In two days afterwards they were killed, when not one of the ſtomachs contained a ſingle pebble, and yet the tubes were bruiſed and flattened, and the ſpherules and bits of glaſs blunted and broken: this happened alike to each body, nor did the ſmalleſt laceration appear on the coats of the ſtomach.

XXXI. I did not confine my obſervations to a ſingle ſpecies. With the ſame view I ſet under a turky-hen ſeveral eggs, ſome her own, and ſome from a common hen. When the chickens were hatched I took charge of them

them myſelf, and employed the ſame precautions as with the wood-pigeons (xxx). They were confined for fifty-five days in ſeparate cages, and their food conſiſted of various ſorts of grain. At laſt I forced them to ſwallow the hard indigeſtible ſubſtances ſo often mentioned. Upon examination, the ſtomachs appeared to be free from ſtones, yet the fragments and ſpherules of glaſs, and the tin tubes, were not on this account either the leſs or the more bruiſed or broken. Hence then we have at length a deciſion of the famous queſtion concerning the uſe of theſe pebbles, ſo long agitated by authors. It appears, that they are not at all neceſſary to the trituration of the firmeſt food, or the hardeſt foreign ſubſtance, which is contrary to the opinion of ſo many anatomiſts and phyſiologiſts, as well ancient as modern; I will not, however, aſſert, that when put in motion by the gaſtric muſcles, they are incapable of producing any effect on the contents of the ſtomach.

XXXII. But for what purpoſe are they deſigned? If they are not neceſſary to the trituration of the food, are we to ſuppoſe that they contribute in any other way to digeſtion? Do they create a keener appetite, or maintain a better ſtate of health, as ſome conceive? Are they

they found in the ſtomach becauſe they are caſually mixed with the food, and as it were concealed by it; or, becauſe they are ſwallowed by choice, and even ſought after?

The firſt queſtions are already anſwered, or rather precluded, ſince we have found, that birds unprovided with pebbles take their food, are nouriſhed and grow juſt as well, and are as briſk and lively as others abounding with them; an obſervation I have made with ſatisfaction upon young pigeons, turkies, and chickens reared in the manner deſcribed above (XXX, XXXI).

XXXIII. The laſt queſtion will be readily ſolved, if grown up chickens take their food in the ſame way as young ones; for theſe ſwallow every thing that comes in their way. I have often ſcattered amongſt them various ſubſtances unfit for their nouriſhment, ſuch as pebbles, bits of brick, chalk, or other rubbiſh, which they pecked with eagerneſs, whether their ſtomach was full or empty. One day I threw among ſome chickens a large quantity of the little fiſh, termed *Lice* by Conchologiſts, which they devoured till their crop was full, juſt as if it had been the moſt agreeable food. If they retain the ſame diſpoſition when full grown, we may reaſonably conclude, that the collecting of pebbles is

leſs

leſs the effect of choice than ſtupidity; as the oſtrich, according to Valliſneri and Buffon, devours without diſtinction whatever comes in its way, ſticks, and ſtones, and cords, and glaſs, and metals, &c. ſuch is its dulneſs, and ſo obtuſe its organ of taſte (*a*). But when fowls are grown to their full ſize, and when their natural inſtinct, which lay dormant while they were young, comes to be unfolded, change their manners in this as well as many other reſpects. A capon confined in a cage by Redi, died of hunger ſooner than it would ſwallow pebbles offered to it in place of food (*b*). With me alſo three hens and a turkey, kept confined, died in the courſe of a few days, when inſtead of giving them food, I ſcattered before them a quantity of ſmall ſtones. After their death, I found that the number of the ſtones was the ſame, though they would appear to be of the moſt proper kind, having been taken from the ſtomachs of other individuals belonging to the ſame ſpecies. When pebbles are mixed with the food, I have obſerved, that poultry eſpecially when hungry, pick them up and ſwallow them. I ſhould then incline to believe,

(*a*) Buffon Hiſt. des Oiſeaux. T. 2. Ed. in 12. Valliſn. Op. in fol. T. 1.

(*b*) Degli Anim. viventi negli Anim. viventi.

lieve, that the ſtomachs of theſe birds generally contain a quantity of ſmall ſtones; not becauſe they are ſought for and ſelected by deſign, as many ſuppoſe, but becauſe they frequently happen to be mixed with their food.

XXXIV. Having ſhewn that the pebbles are not the cauſe of trituration of the food and other ſubſtances, we muſt conclude, that it is the ſole and immediate effect of the gaſtric muſcles, which, as it is well known, are very ſtrong, and compoſed of firm and compact layers, and muſt, therefore, when ſet in motion, act with great force. To be more fully ſatisfied of this, let the ſtomach of a dog, ſheep, or a man be compared with the gizzard of a duck, turkey, or gooſe; we ſhall then perceive the enormous difference between the thick muſcular coat of the one, and the thin one of the other.

XXXV. The internal coat, or that which immediately lines the cavity of the ſtomach, deſerves particular attention. In many animals, and in man himſelf, it is ſoft and villous; but in gallinaceous birds it is hard and cartilaginous. When ſeparated from the next, which anatomiſts call the nervous coat, it ſoon becomes dry and very hard. In turkies and geeſe, in which it is thicker and ſtronger than in common fowls, I have

I have often dissected it away, and spreading it upon a table, have drawn along it lancets, needles, bits of glass, and such sharp substances as are triturated in the stomach without any perceptible injury to it. If indeed I pressed with considerable force, those parts, over which the keen bodies passed, were disunited, whether it was separated or adhered to the other coats.

XXXVI. But these substances may act in a quite different manner when under the direction of the hand, than when set in motion by the gastric muscles, and when the internal coat is not extended but forms a cavity, as it does when the stomach is entire. I therefore wished to know what happens to substances inclosed in the stomach separated from the animal, and pressed externally with the palms of both hands, and agitated in various directions. The stomach of a turkey hen was first cleared of its contents by forcing them out through the pylorus, and then a large quantity of sharp pieces of glass were introduced, which were kept in motion for a quarter of an hour by pressure and percussion on the outside of the stomach. I was in hopes, that I should thus, in some measure, imitate the natural motion. Nor was the expedient altogether ineffectual; for the internal

internal coat was only perforated with two little holes, ſuch as the point of a needle would have made, and yet part of the glaſs was reduced to powder, and part had loſt its ſharp edges. Different effects then are produced, when this coat is ſubmitted to experiment after it has been removed from its natural ſituation, and when it adheres to the others. Nevertheleſs I am willing to allow, that how it ſhould be capable of blunting and breaking the keeneſt bodies without ſuſtaining any injury itſelf, ſtill continues a matter of great ſurprize.

XXXVII. But if the inſide of the gizzard be certainly agitated ſo violently during the trituration of the food, will not the motion be perceptible on the outſide? Reaumur, induced probably by this reflection, laid open the abdomen of ſome of the fowls in queſtion, and watched the ſtomach, but could not perceive what he perhaps imagined took place. They always ſeemed perfectly at reſt, except the gizzard of a capon, which contracted and dilated alternately; he moreover ſaw certain fleſhy cords moving in an undulating direction, but very ſlowly and gradually (*a*).

(*a*) Mem. cit.

XXXVIII. I

XXXVIII. I have perceived ſimilar motions in two turkey cocks. Upon preſſing the ſtomach forcibly with my hand, I felt a ſlight pulſation that produced a ſenſation of creeping, but was ſoon aware, that this was owing only to the beating of numerous little arteries, which run upon the ſurface of the viſcus. When a perforation is made in the heart of a living animal, and a finger introduced through it, it is well known that ſtrong preſſure is felt at the time of its contraction. I made this experiment upon the gizzard of a duck, but was not ſenſible of the ſlighteſt compreſſion.

Conceiving that the ſtomach muſt exert its principal action when it is irritated by ſubſtances filling its cavity, I introduced ſome nuts into the gizzard of a turkey hen, that had been kept faſting for a day. During the whole time I watched it attentively, through an opening made in the abdomen; when it had received only a few nuts it ſhewed no ſign of motion, but when it was nearly full it ſwelled violently, and then collapſed again of a ſudden. Theſe alternations were ſometimes general, and at others confined to a narrow ſpace; they did not continue ten minutes, probably becauſe the aperture of the abdomen was bringing on the death of the

the animal. The nuts were unbroken, but evident contusions appeared upon their surface. This distinct view of the motions of the stomach I ascribe to unusual good fortune, since, with the exception of only one other turkey, the stomachs of many birds of the same class remained at perfect rest, after they had been filled in the same manner. If however we consider the very morbid state of the animal when the abdomen is laid open, we shall not be much surprized at this phænomenon.

XXXIX. The various facts related in the preceding paragraphs irrefragably prove, that the food of ducks, fowls, geese, partridges, &c. must undergo the mechanical action of the gastric muscles, before it can be broken down, and reduced to an impalpable pulp. But are we to suppose, that digestion depends on this action, and that simple trituration converts the aliment into that pultaceous mass denominated *Chyme*? Or rather, that this mass is generated by means of juices either prepared or collected in the stomach; and that trituration is a co-operating, but not the immediate cause of digestion? I imagined that the tubes and spherules, which had already afforded me so much information, would not now be without their use. If the gastric

gastric juices convert into chyme the food which trituration has prepared for digestion, let some food so prepared be inclosed in the tubes and spherules, and let us see whether it will be dissolved according to this hypothesis; for then it must be thoroughly soaked in those juices. I accordingly filled a tube and spherule with crumb of wheaten bread masticated, and introduced both into the gizzard of a hen. In three and twenty hours they were taken out, when the bread was much diminished in quantity, especially at the ends of the tube, where it was also softer than at first, and had acquired a bitter taste. The same tube and spherule were forced into the gizzard of another hen, where they remained fourteen hours; after which there was no appearance of bread in either.

XL. I repeated this experiment upon a third hen, with bread of maize instead of wheat; the tube and sphere were emptied in a day and half. As there was here no trituration nor any other power, except the action of the gastric fluid, it seemed reasonable to conclude, that this fluid had dissolved and converted the bread into chyme, and so enabled it to pass through the holes in the receivers. A doubt however suggested itself, and kept me in suspense; without supposing

the tranſmutation of the bread into chyme, the gaſtric fluid by merely diluting it, like water, might render it capable of paſſing out of the tubes and ſpherules.

XLI. A ſubſtance not ſoluble by ſimple maceration, and at the ſame time ſofter than grain, upon which the gaſtric juices have no action (III, IV, V, VI, VII.), was wanting to clear up the doubt. Fleſh ſeemed to correſpond to this deſcription. Fleſh is digeſted by many birds with gizzards, which for the moſt part are both frugivorous and granivorous; I therefore filled four tubes with veal (*a*) bruiſed very ſmall in order to ſupply the want of trituration, and forced them into the ſtomach of a hen. They were taken out in twenty-four hours, and the fleſh was in the following ſtate: In the tube that came firſt to my hands it did not amount to above one-twentieth of its original bulk, in two others it had ſuffered nearly the ſame diminution; the only difference appeared in the fourth, which was not open at both extremities like the other three, but cloſed at one end with a circular plate of iron. The fleſh contiguous to the plate preſerved its red colour and na-

(*a*) Wherever I mention fleſh without an epithet. I mean raw fleſh.

tural

tural conſiſtence, and did not ſeem at all waſted; but at the open end it was reduced to two thirds of the length of the tube, of which it had at firſt occupied the whole; the part that continued firm and red retained the true flavour of fleſh; at the oppoſite end it had entirely loſt that flavour, and the ſurface, to the depth of a full line, was beſides reduced to a pulp, and had acquired a cineritious colour. The inconſiderable reſiduums in the other tubes were altered in the ſame manner.

The immediate conſequences of theſe experiments are ſelf-evident. The remarkable diminution of the fleſh aroſe from its having been in great meaſure diſſolved and digeſted; for all phyſiologiſts agree in conſidering the change of colour and taſte, and the tranſmutation of the food to a pultaceous maſs in the ſtomach, as the characteriſtic marks of digeſtion. The three tubes, of which the ſides were perforated and the ends open, admitted the gaſtric liquor at every part. Hence a conſiderable waſte of the fleſh in them. The caſe was different in the tube cloſed at one extremity, and nothing can be more obvious than the reaſon; for as the liquor could only enter at one end, it could only there diſſolve the fleſh.

 XLII. This

XLII. This experiment decifively proves, that the gaftric liquor was the cauſe of digeſtion in the preſent inſtance; and it was eaſy to foreſee, that others upon the ſame claſs of birds would be attended with the ſame reſult. Some tubes filled with fleſh were next introduced into the gizzard of a very large turkey cock, but the lattice work at the open ends, though it conſiſted of iron, could ill withſtand the action of ſuch powerful muſcles. Upon examination ſeven hours afterwards, it was found ſeparated from the tubes, and coiled up in one maſs near the pylorus, in the midſt of the pebbles and ſcoriæ of the food, ſome of which were jammed ſo tight in the tubes, that there was difficulty in forcing them out with the point of a penknife. I could not perceive the ſmalleſt fragment of fleſh amongſt them, and remained in doubt whether it had been digeſted, or expelled by theſe extraneous bodies. I reſolved to ſubmit this ſpecies of bird to further experiments, but was obliged to abandon the tubes, and have recourſe to the hollow ſpherules, of which I have ſpoken above (VII). They were made thick and ſtrong, with many ſmall pores over the whole ſurface, in order to obviate two inconveniencies, the one leſt the receivers ſhould be unable to reſiſt the violent

impulſes

impulſes of the ſtomach, the other to prevent the matters compreſſed and agitated by the action of the muſcles from entering ſo readily into them. Two of theſe ſpheres were given to a turkey cock eleven months old, and in twenty-four hours were taken out of the gizzard. They contained at firſt about twenty-eight grains each of beef and veal bruiſed very ſmall. Upon opening them after the ſame interval as before, and weighing the fleſh, the beef was found to have loſt nine, and the veal thirteen grains. I muſt not however omit to remark, that they were both fully impregnated with gaſtric liquor, and conſequently would have weighed ſtill leſs if they had been free from it. The beef and veal, when touched with the point of a knife, ſeemed tenderer than in their natural ſtate, and reſembled a ſoft paſte rather than fleſh. They had the bitter taſte of the gaſtric juice with which they were impregnated, and the colour approached more to white than red. They were replaced in the ſphere, and kept twelve hours in the gizzard of another turkey-cock. Upon a freſh examination, the beef weighed only eight, and the veal only five grains. The gaſtric fluid had therefore produced a new ſolution, and this proceſs was entirely completed after the ſpheres, into

which the flesh was put for the third time, had continued five hours in the stomach of a third turkey cock.

XLIII. Flesh is digested by the gastric liquor of geese as well as of turkies. Eleven grains of beef, inclosed in a spherule, were entirely dissolved in two days in the gizzard of one of these large birds.

I will not describe three other results obtained, one from an hen, and the two others from two capons; since, with respect to the digestion of the flesh, they are exactly like those just mentioned.

All these experiments were made with flesh bruised very small; this condition is not indeed indispensably requisite, but it very much promotes digestion. The bruised flesh was always dissolved in two days, but when entire that process was not completed in four, and sometimes not even in five days. The reason of this difference is obvious. The more flesh is bruised, the larger surface does it acquire; and in proportion to the increase of surface, more points are exposed to the action of the gastric liquor, which will consequently sooner complete the solution.

XLIV. Before I proceed further and conclude the present dissertation, I must notice an experiment of Reaumur, which does not perfectly

perfectly agree with thoſe juſt related. The greateſt part of his memoir is employed in ſhewing the great force of the gizzard of gallinaceous fowls in triturating the food; in the remainder he endeavours to prove, that this viſcus contains no menſtruum of ſufficient efficacy to produce ſolution. In ſupport of this propoſition, beſides the argument derived from barley continuing unaltered within the tubes, he adduces the following fact, which requires to be particularly related. It is well known, how greedily ducks devour, and how ſoon they digeſt, fleſh. In order therefore to obtain the information he wanted, Reaumur had recourſe to this bird. Having provided ſix tubes, four of lead, and two of tin, he incloſed in the former bits of veal of the ſize of a grain of barley, and in the latter ſome conſiderably larger. Theſe ſix tubes he gave to a duck at different times; viz. a leaden one at ten o'clock in the morning, and another at eight in the evening; next day a third was given at ſix in the morning, together with the two tin tubes; laſtly, at nine the ſame morning the animal was made to ſwallow the laſt leaden tube, and at ten was killed. Of the four leaden tubes, one was voided the preceding day at nine in the evening; it was that which had been

taken

taken at ten in the morning; the other five remained in the gizzard, and the flesh was not only entire, but as firm as at first. Some of the pieces retained their red colour, three of them however had lost it. Of some of the tubes the whole capacity was no longer filled by the flesh; not that it had suffered any diminution, but because it was compressed by the stones and food, which had been admitted at the open ends of the tubes. From this experiment Reaumur infers, that no menstruum had acted on the flesh, since it was not either comminuted or dissolved. And though he does not affirm, that in the gallinaceous class digestion is the effect of trituration alone, he yet concludes, that the gizzard contains no solvent capable of decomposing and digesting the aliment.

XLV. What has been above related, shews how far Reaumur's conclusion ought to be extended; when we speak of aliment of a hard and compact texture, such as seeds, it must be allowed, that the gastric liquor has no action upon them (II, III, IV, V, VI, VII.); but when we are considering food naturally tender, as flesh, or such as is made so by art, as grain in the form of masticated bread, it must then be allowed, that a perfect solution is effected by the gastric juices alone (XXXIX,

(XXXIX, XL, XLI, XLII, XLIII.). In Reaumur's experiment the fleſh remained ſo ſhort a time in the gizzard, that we cannot be ſurprized if it was not ſenſibly diſſolved. If we attend to the times at which he gave his tubes to the duck, and at which he killed it, we ſhall immediately perceive, that the tube which continued longeſt in the gizzard, remained in it only twenty-four hours; a ſpace inſufficient, according to my experiments on fowls, turkies, and geeſe (XLI, XLII, XLIII.), for the gaſtric liquor of theſe birds to diſſolve any ſenſible portion of fleſh incloſed in tubes. I ſhould however have condemned myſelf for a crime of omiſſion, if, to the proof deducible from analogy, I had neglected to add direct experiments on ducks. Upon two ducks therefore I repeated the experiment of the French Naturaliſt, with the following variation; four tubes, each containing a bit of veal equal in ſize to a barley-corn, were given to a duck; in two of the tubes the fleſh was whole, but in the two others it had been previouſly cut into ſmall bits: in fourteen hours the gizzard was examined; the four tubes were found in it; the two entire pieces of fleſh were of their original ſize, but inclining to a white colour; the ſmall bits were alſo about the ſame ſize as at firſt, but were

were converted into a gelatinous paſte. The experiment was repeated upon another duck, which was not killed till the end of the ſecond day; and now the tubes that had contained the minute bits of fleſh were entirely empty; and in the others, only ſome ſlight traces of a gelatinous concocted matter remained. If we combine theſe facts with others before related, it will appear, that in the gallinaceous claſs, trituration and the gaſtric fluid mutually aſſiſt each other in performing the important function of digeſtion; the former by breaking down the aliment, acts as the pre-diſpoſing cauſe; the latter, when it is thus prepared, penetrates into it, deſtroys the texture, diſſolves the particles, and diſpoſes them to change their nature, and to become animalized.

XLVI. But what is the origin of this gaſtric fluid, ſo uſeful in digeſtion? How is it mixed with the food? And what ſucceſſive changes does the latter undergo from the action of trituration, joined to that of the gaſtric liquor? Theſe important queſtions required a ſtrict examination of the œſophagus and gizzard, as alſo of the food during its paſſage through theſe parts, and continuance in them. As experiments are more concluſive, the greater the ſcale is, on which they are conducted,

ducted, I conceived that the larger ſpecies, as geeſe, turkies, ducks, and fowls, would be the beſt ſubjects for theſe enquiries. To begin then with the œſophagus of a gooſe, this canal at the end towards the mouth, has the appearance of an inflated inteſtine; it is above a foot long, and at its origin about an inch in diameter, but widens as it deſcends, for the ſpace of ſix inches and more, when it contracts like a funnel, then enlarges again, and this enlargement continues to the gizzard. The œſophagus is membranous, its ſides are ſtrong and thick; they are thickeſt at three inches diſtance from the ſtomach, on account of a fleſhy faſcia, of which I ſhall ſpeak below. If we look very attentively, we can perceive the whole œſophagus covered with points or elongated ſpots, which are moſt numerous juſt above the funnel. The faſcia appears to conſiſt of a multitude of cylindrical bodies, ſomewhat larger than huſked millet-ſeed. Theſe bodies are ſeen through a fine membrane, which ſurrounds the faſcia externally.

XLVII. If the œſophagus be inverted, and the ſpots examined by the help of a glaſs, we plainly perceive that they are follicular glands. This likewiſe is confirmed by the appearance of moiſture on the œſophagus, when they are preſſed.

preſſed. But the follicular glands that appear through the fleſhy faſcia like cylindrical bodies, bigger than millet, as we before obſerved (XLVI), are far more eaſily diſtinguiſhable, becauſe far larger. This faſcia, which encircles the œſophagus like a ring, is above an inch in breadth, and about a line in thickneſs. Great part of it is inveſted by a covering of a deep yellow colour, very thin and conſequently very liable to be torn. When this is removed, the faſcia externally appears white and rough, on account of the numberleſs prominent papillæ, each of which has a palpable pore in the center. When the faſcia is ſtretched, and ſtill more when it is preſſed between the fingers, a drop of whitiſh turbid liquor guſhes out at each pore into the œſophagus; and it may be increaſed, by continuing the dilatation or preſſure. The liquor is denſe, ſomewhat viſcid, of a ſweetiſh, and at the ſame time ſaltiſh taſte. To comprehend immediately that the pores are the excretory ducts of the follicular glands lying below, requires very ſlight anatomical knowledge: the glands appear very diſtinctly, when the membrane in which the pores are inſerted, is removed. The follicles are of a pale red colour, and full of a turbid liquor, which

which oozes out from the excretory ducts, when the œsophagus is kept under water.

XLVIII. Below the fleshy fascia, the œsophagus becomes membranous again for nearly the breadth of three quarters of an inch, when it is inserted into the gizzard. This organ is of the size of the fist, remarkably hard, and of an irregular elliptical figure; when opened lengthwise at the thinnest part, it is divided into two large muscles, each above an inch in thickness, and composed of very compact fibres. It appears plainly, that the whole action of these great muscles consists in approximating with violence, and like the sides of a vice, crushing and breaking to pieces all interposed substances. As the nervous coat adheres to these strong muscles, and as, however robust, it might be injured by such impetuous shocks, nature has sagaciously invested it with a cartilaginous coat, of a structure more capable of resistance, which internally lines the cavity of the gizzard.

XLIX. In turkeys the œsophagus and stomach very nearly resemble the same parts in geese. The former, however, is more membranous, and abounds more in follicular glands of a larger size, and consequently more conspicuous. The excretory ducts may be easily

eaſily ſeen, and the liquor of the follicles may be readily forced out by preſſure. This liquor is tranſparent, and ſomewhat viſcid; its taſte is rather ſweet. But the œſophagus of the turkey has one peculiarity not found in the gooſe; it is provided with a burſa or bladder, well known under the name of the *crop* or *craw*. In this ſpecies it is very large. The crop at the ſides at leaſt, if not at every part, is furniſhed with follicular glands, exactly like the others. At the lower part of the œſophagus we alſo find the fleſhy faſcia, an inch in breadth, and provided with follicles much larger than thoſe of the crop or œſophagus, and in great abundance. The liquor ſeems to have the ſame properties as in the gooſe. It is viſcid, has a ſweetiſh and ſaltiſh taſte, a turbid white colour, and conſiderable denſity.

The gizzard, whether its form or the nature of its coats be conſidered, is exactly like that of the gooſe, only weaker and ſmaller in proportion to the inferior ſize of the bird.

L. I have obſerved all that has been related with reſpect to the gizzard and follicular glands of the gooſe and turkey in due proportion in the duck, common fowl, and even in ſmaller birds of the ſame claſs, as the pigeon, partridge, wood-pigeon, turtle-dove,

and

and quail; with this peculiarity only, that in the duck the œſophagus, inſtead of forming a crop, has the ſame ſtructure as in the gooſe (XLVI). I ſhall therefore omit a deſcription of theſe parts, and proceed to conſider the ſtomach in a phyſiological light.

LI. In ſpeaking of this organ, I have never mentioned either follicles or glands; for in the fowls hitherto mentioned, I could never diſcover any. The internal coat, from its cartilaginous nature, appears to be unfit for the inſertion of glandular bodies; at leaſt I was not able to find the ſmalleſt veſtige of them; nor did I ſucceed any better in the nervous or muſcular coats, notwithſtanding I examined them very narrowly. Reaumur having obſerved a vaſt number of ſhort white filaments between the cartilaginous and nervous coats, entertained ſome ſuſpicion of their being tubes or veſſels, placed there in order to diſcharge their contents into the ſtomach (*a*). I have found theſe filaments in all the gallinaceous fowls I have examined; but cannot agree with him that they remain attached to the nervous, when the cartilaginous coat is ſeparated from it: for after ſuch ſeparation, I have ever ſeen them adhere to

(*a*) Mem. cit.

the cartilaginous, never to the nervous coat; but any perſon may readily make the trial. Theſe filaments are very numerous; they are pointed at the extremity, oppoſite to that which is inſerted into the cartilaginous coat, and reſemble ſhort white down, diſtinctly viſible by the naked eye in the larger birds; ſuch as the gooſe and turkey, but requiring the aid of a glaſs to be ſeen in the ſmaller ſpecies. I have divided many of various ſizes with the points of very fine needles, in order to diſcover whether they were hollow or glandular, but could never find any appearance of this kind: I have alſo ſqueezed them in order to ſee if any liquor would ooze out, but to no purpoſe: and ſo far from ſuſpecting theſe filaments of Reaumur to be vaſcular or glandular, I ſhould rather ſuppoſe them to be merely for the purpoſe of joining, or at leaſt more cloſely connecting the cartilaginous with the nervous coat.

We ſhall ſee elſewhere, that ſtomachs of the membranous kind, when they are taken out of the animal and rubbed dry, ſoon become moiſt again: this moiſture comes from inviſible veſſels and glands, diſcharging their liquor into the cavity of the ſtomach. I have made the ſame experiment on muſcular ſtomachs, but they always continued dry; the

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ſame thing alſo took place, when I preſſed them underneath, though this is a very effectual means of accelerating and increaſing the covering of moiſture. Hence I have good reaſon to ſuppoſe, that the juices found in muſcular ſtomachs do not properly belong to them, but come chiefly from the œſophagus, and in part from the duodenum, as we ſhall ſee below.

LII. Nature however, has not failed to provide the quantity neceſſary for digeſtion. We have ſeen the vaſt number of follicular glands with which the œſophagus is provided (XLVI, XLVII, XLVIII, XLIX.); they muſt needs pour in their liquor in great abundance. And experience confirms what reaſon ſuggeſts. I introduced a ſmall piece of dry ſpunge, previouſly cleanſed from every impurity, into the craw of a pigeon, in which it was left twelve hours; at the expiration of which time I opened the craw, and took it out. The ſpunge was full of liquor, and on being ſqueezed into a glaſs, afforded above an ounce. I employed larger pieces of ſpunge in fowls and turkeys, and obtained more of this œſophageal liquor; the quantity in a turkey amounted to ſeven ounces in ten hours. A ſimilar liquor is procured in equal abundance, from ſuch œſophaguſes as are dilated into a

large canal, inſtead of a craw, as in ducks and geeſe (XLVI, L.). This fluid is undoubtedly deſigned to ſoften the food which remains a certain time in the craw, or in the large canal; which not only diſpoſes it to be more readily broken down, but very probably alſo communicates to it ſome quality that renders it more eaſily digeſtible. But it is likewiſe certain, as I have found from experiment, that a conſiderable part of this fluid deſcends into the ſtomach; not to mention that denſer and more viſcid liquor which diſtils from the fleſhy faſcia, lying at the bottom of the œſophagus, (XLVI, XLVII.).

LIII. Theſe various œſophageal juices acquire in the ſtomach a bitter flavour, reſembling that of the food in this viſcus: and as this taſte exactly reſembles that of the bile, which in theſe animals is diſcharged through the cyſtic duct into the duodenum, I am thoroughly perſuaded that it ariſes from this ſource, in conſequence of the bile regurgitating into the cavity of the ſtomach, and being mixed with the food and œſophageal liquors collected there. I am confirmed in this perſuaſion by other facts, for the relation of which I ſhall find a more convenient place; not to mention the well known circumſtance

of

of the bile being found in the ſtomach of various animals (*a*).

LIV. This collection of divers liquors in the gizzard of our fowls, ſerves as a menſtruum for the food, and diſpoſes it to be tranſmuted into chyle. But the firſt ſtep towards this event is taken in the craw. It is there that the aliment is penetrated by the œſophageal liquor, and begins to change its ſmell and taſte: that of the hardeſt texture is prepared to be broken down when it diſcends into the ſtomach, which in theſe birds may be ſaid to ſupply the place of teeth.

But the way in which the food deſcends from the mouth into the ſtomach, is deſerving of attention. When our fowls are abundantly ſupplied with meat, they ſoon fill their craw: but it does not immediately paſs hence into the gizzard, nor does not arrive there till after it has been macerated in the craw: it always enters in very ſmall quantity, in proportion to the progreſs of trituration in the ſtomach. Here then, what happens in a mill, may be obſerved to take place. A receiver is immoveably fixed above the two large ſtones which ſerve for grinding the corn;

(*a*) Haller Elem. Phyſiol. T. 6. Valliſn. Op. in Fol. T. 1.

this receiver lets the corn which it contains, fall continually in ſmall quantity into the central hole in the upper ſtone, through which it paſſes, and diffuſes itſelf in the void ſpace between the two ſtones, where it is broken down, triturated, and pulverized by means of the ſtrong friction of the upper ſtone that moves round with great velocity upon that below. Meanwhile the flour paſſes from between the ſtones, as ſubſtances triturated by the gizzard, and diſſolved by the gaſtric juices, are expelled through the pylorus into the ſmall inteſtines.

LV. All this may be obſerved, by inſpecting the alimentary canal during the time of digeſtion. If the bird has fed upon grains, they are found in the cavity of the gizzard, partly entire, but ſoftened by a fluid. That part of the œſophagus that lies between the end of the crop and the beginning of the ſtomach, either contains no grains at all, or only a few quite entire. Trituration takes place in the gizzard only. Thoſe which have firſt entered this cavity, are found to have loſt the farinaceous ſubſtance, and are reduced to mere bran; the ſucceding ones are more or leſs broken, and the laſt are entire. Amid this mixture of bran, and broken and entire grains, we always find a ſemi-fluid pul-

taceous

taceous maſs of a whitiſh yellow colour. This is the farinaceous parts of the grains decomposed by the gaſtric liquor, and converted into chyme. Meanwhile freſh grains continue to fall into the gizzard, in order to undergo the ſame tranſmutation: this admirable proceſs continues as long as any grains continue to fall into the ſtomach.

Theſe appearances and changes take place alſo in animal ſubſtances, whenever birds with muſcular ſtomachs feed upon them.

LVI. At whatever time the ſtomachs of theſe birds happen to be opened, they always contain a certain quantity of gaſtric liquor. But it is leſs abundant when they are full of food, (being in this caſe abſorbed by the food) than when they contain little or none. If we wiſh therefore to be provided with a large quantity of this liquor for experiments, it ſhould be taken from the empty ſtomach. Beſides, in this caſe it is purer than when mixed with the food. When examined in a ſtate of purity, its tranſparency, if we except a ſlight yellow tinge, is little inferior to that of water. It has likewiſe the fluidity, but not the inſipidity of water, being always a little bitter, as well as ſalt. I have found that the gizzards of turkeys and geeſe abound moſt in gaſtric juices, probably on account of

their ſuperior ſize. I was induced by the quantity they afforded to attempt an experiment, which if it ſucceeded, would ſtill further prove that trituration is only an aſſiſting or prediſpoſing, and not the efficient cauſe of digeſtion. It conſiſted in trying, whether theſe juices retain their ſolvent power out of the ſtomach. For this purpoſe, I took two tubes ſealed hermetically at one end, and at the other with wax: into one I put ſeveral bits of mutton, and into the other ſeveral bruiſed grains of wheat, and then filled them with the gaſtric liquor. In order that they might have that condition which in theſe animals precedes digeſtion, they had been macerated in the craw of a turkey cock. And as the warmth of the ſtomach is probably another condition neceſſary to the ſolution of food, I contrived to ſupply it by communicating to the tubes a degree of heat nearly equal, by fixing them under my axillæ. In this ſituation I kept them at different intervals for three days, at the expiration of which time I opened them. The tube with the grains of wheat was firſt examined; moſt of them now conſiſted of the bare huſk, the flour having been extracted, and forming a thick grey ſediment at the bottom of the tube. The fleſh in the other tube was in great meaſure

ſure diſſolved, (it did not exhale the leaſt putrid ſmell) and was incorporated with the gaſtric juice, which had become more turbid and denſe. What little remained had loſt its natural redneſs, and was now exceedingly tender. Upon putting it into another tube, and adding freſh gaſtric liquor, and replacing it under the axilla, the remainder was diſſolved in the courſe of a day.

I repeated theſe experiments with other grains of wheat bruiſed and macerated in the ſame manner, and likewiſe upon ſome fleſh of the ſame kind, but inſtead of gaſtric juice I employed common water. After the two tubes had remained three days under my axillæ, I found that the grains, where they were broken, were ſlightly excavated, which was occaſioned by an incipient ſolution of the pulpy ſubſtance. The fleſh had alſo undergone a ſlight ſuperficial ſolution, but internally it appeared fibrous, red, firm, and in ſhort, had all the characters of fleſh. It was alſo putrid; the wheat too had acquired ſome acidity, two circumſtances, neither of which took place in the grains and fleſh immerſed in the gaſtric liquor. Theſe facts are then irrefragable proofs that the gaſtric juice, even out of its natural ſituation, retains the power

power of diſſolving animal and vegetable ſub-ſtances in a degree far ſuperior to water.

LVII. The gaſtric juice which I employed was taken from a turkey. That of a gooſe produced ſimilar effects. I have further found, that in order to operate the ſolution of animal and vegetable ſubſtances, this juice ſhould be freſh. It loſes its efficacy, when it has been kept ſome time in veſſels, eſpecially if they ſhould happen to be open. It alſo becomes inefficacious after it has been uſed for one experiment. Laſtly, a conſiderable degree of heat, equal to the temperature of man or birds, muſt be applied; otherwiſe, the gaſtric juices are not more effectual in diſſolving fleſh and vegetables than common water. This artificial mode of digeſtion is well calculated to illuſtrate the ſubject I have undertaken to treat; but I ſhall have opportunities of ſpeaking of it at greater length in the ſubſequent diſſertations.

DIS-

DISSERTATION II.

ONCERNING THE DIGESTION OF ANIMALS WITH AN INTERMEDIATE STOMACH. CROWS. HERONS.

VIII. BY the term intermediate ſtomach, I mean ſuch a ſtomach as, on he one hand, is not properly muſcular, that , provided with thick and ſtrong ſides, as the gallinaceous family (1.); and on the ther, is not merely membranous, that is, ery thin, as in birds of prey and man, but as an intermediate degree of thickneſs and rength. The ſtomachs of both the raven (*a*) nd grey crow (*b*) may be conſidered in this ight, though in reality they approach nearer o the muſcular than the membranous claſs.

(*a*) Theſe two ſpecies are called by Linnæus, Corvus cineſcens, capite, jugulo, alis caudaque nigris.
Corvus ater, dorſo atro-cœruleſcente, cauda ſubrotunda.

(*b*) The hooded crow of Pennant. Corvus Cornix L.

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The intermediate power of theſe ſtomachs contributes alſo to characterize them; it is very far from being equal to the force of muſcular, but greatly exceeds that of membranous ſtomachs. Such tubes of tin, as doves and pigeons would flatten and disfigure with the greateſt eaſe, remain unaltered in the ſtomach of crows. Thus alſo grain is triturated by the former, but continues whole in the latter. Their gaſtric muſcles however are not inert. They exert a certain degree of action, but it is far inferior to that of the gizzard in the gallinaceous claſs. Thus though they cannot compreſs tin tubes, they are capable of producing this effect upon tubes of lead, provided they are very thin: and thoſe that continue unaltered at firſt, are at length ſlightly incurvated or diſtorted at the edges, and generally filled with fragments of the food, evident marks of conſiderable action in the gaſtric muſcles; there are no effects which ſhew ſuch action in animals with membranous ſtomachs, as we ſhall find in its proper place. I have often ſeen theſe phænomena, having kept a great number of grey crows and ravens, which have been very ſerviceable in the courſe of my enquiries, as the reader will learn from a peruſal of the preſent diſſertation.

LIX. Theſe

LIX. Theſe birds may, as well as man, be enominated *omnivorous*. Herbs, graſs, ſeeds f leguminous plants, fleſh of every kind, live or dead, ſerve equally for their nouriſh-nent. As the powers for the concoction of arious aliments, poſſeſſed by theſe ſpecies are ither entirely the ſame as, or ſtrongly reſem-le thoſe of man, it is obvious, that the nowledge obtained from them will greatly luſtrate the proceſs of digeſtion in us. They eſides ſeem formed on purpoſe to forward he views of the obſerver. When we wiſh o know what changes have been produced n ſubſtances incloſed in ſpheres and tubes, nd given to gallinaceous birds, it is neceſſary o extract the tubes and ſpheres from their izzards; that is, it is neceſſary to kill them. Hence for every experiment we muſt ſacri-ice an individual, at no ſmall expence to our hiloſophical curioſity. On the contrary, ve can perform ſuch experiments upon crows s often as we pleaſe, without deſtrowing a ingle individual. With reſpect to ſubſtances hey are incapable of digeſting, ſuch as the bove-mentioned metallic receivers I have liſcovered, that they poſſeſs the privilege of eturning them through the mouth, as birds f prey vomit the feathers and hair of the ani-mal they have devoured, a circumſtance well known

known both to naturalists, and those who train falcons for the field. But whereas this vomiting generally takes place every twenty-four hours in birds of prey, in crows it happens at least every nine, and commonly every two or three hours.

LX. As I obtained the same results from both species, I shall employ in my narration the generic name only (*a*). My observations were begun in winter, the most convenient season for procuring a large number, owing to the multitudes, especially of ravens, with which Austrian Lombardy, and indeed almost all Italy then abounds. All the crows which I could obtain, had when newly taken, a large collection of pebbles in the stomach; the biggest were of the size of small pease, the least of that of millet: they were of various sorts; I even found rounded pieces of brick. But in less than ten days not a stone remained in the body, a circumstance which I learned from the inspection of several stomachs, when I had occasion to kill some crows in order to observe the anatomical structure of the alimentary canal. They were voided partly at the anus, as appeared from the excrements,

(*a*) Corvus is the generic name in Latin, and Cornachcia in Italian, and Crow may very well serve for it in English.

and

and partly by the mouth; in the latter inſtances they were glued by the gaſtric liquor to the outſide of the tubes which I had forced them to ſwallow, and which they afterwards threw up. When unprovided with pebbles, they continued to eat and were nouriſhed as well as before. Hence it is to be inferred, that they are not more neceſſary to digeſtion in birds with intermediate, than in thoſe with muſcular ſtomachs, as we have ſeen above (XXXI). And as I inclined to believe, that the laſt mentioned claſs do not pick up theſe ſtones from choice, but by mere accident (XXXIII); ſo I conſider the matter likewiſe with reſpect to crows, having obſerved, that though unprovided, they never peck them eagerly, even when hungry, but ſwallow them only when they happen to be mixed on purpoſe or by chance with their food, and as it were concealed by it.

LXI. I began my experiments by putting whole beans or grains of wheat in the tubes (*a*). The reader will eaſily perceive, that crows are not ſo ſtupid as to take the tubes ſpontaneouſly, but that it is neceſſary to force them down the throat, and to paſs the finger

(*a*) Theſe tubes were the ſame I uſed for gallinaceous fowls, and I continued to employ them in the ſequel.

along

along with them till they are got into the ſtomach. This I executed in the way I had before done in animals with muſcular ſtomachs (III). The tubes were all thrown up in the ſpace of three hours. The beans and wheat appeared as at firſt, excepting that they were ſomewhat ſoftened and ſwelled by the gaſtric juice, which had penetrated a little way into them. I replaced the grains in the tubes, and introduced them again into the ſtomach, where they remained two hours longer, without undergoing any further change. I repeated the ſame experiment a great number of times, and upon computing the ſpace during which the tubes had continued in the ſtomach, I found that it amounted to forty-eight hours; in this interval the ſeeds had ſuffered no other alteration, except in being a little more moiſtened. The gaſtric fluid is therefore incapable of effecting the ſolution of theſe vegetable matters.

LXII. But we have before ſaid, that they were entire; on which account, it could not act upon the farinaceous ſubſtance of the grain till it had traverſed the huſk; and this might have diminiſhed its efficacy. In order to determine how far this ſuſpicion was well-founded, it became neceſſary to repeat the experiment upon the ſame ſeeds bruiſed.

Accord-

Accordingly four tubes full of the coarſe flour were given to a crow: they remained eight hours in the ſtomach, and proved the juſtneſs of my ſuſpicion; for upon examining the contents, I found above a fourth part wanting. This could ariſe from no other cauſe but ſolution in the gaſtric liquor, with which the remainder was fully impregnated. Another obſervation concurred to prove the ſame propoſition: the largeſt bits of wheat and bean were evidently much diminiſhed; this muſt have been owing to the gaſtric liquor having corroded and diſſolved good part of them, as the nitrous acid diluted with a large quantity of water, gradually conſumes calcareous ſubſtances. I replaced what remained of the ſeeds in the tubes, and introduced them again into the ſtomach, wherein they remained, at different intervals, twenty-one hours; when they were entirely diſſolved, nothing being left but ſome pieces of huſk and a few inconſiderable fragments of the ſeed.

LXIII. Wheat and beans floating looſe in the cavity of the ſtomach, undergo the ſame alteration as in the tubes. When I fed my crows with theſe ſeeds, I obſerved, that before they ſwallowed them they ſet them under their feet, and reduced them to pieces by repeated ſtrokes of their long and heavy beaks.

And now they digested them very well; nay, this process was very rapid in comparison of that which took place within the tubes. But when the birds either from excessive hunger or violence swallowed the seeds entire, the greatest part of them passed out entire at the anus, or were returned by the mouth. We cannot therefore be surprized, that the gastric juice could not dissolve them within the tubes, since it was incapable of effecting this process within the cavity of the stomach, where its solvent power is far superior.

LXIV. To avoid prolixity, I shall not speak of other seeds submitted to the same experiments; such as chicken-pease, French beans, pease, and nut-kernels. I will rather mention vegetable matters of a softer and more yielding texture, which did not require to be broken down in order to be dissolved; such as crumb of bread and apples. These substances were not only dissolved within the tubes, but required a much shorter time than beans and wheat. Several bits of a ripe apple, weighing together eighty-two grains, and inclosed in tubes, were dissolved in the space of twenty-four hours in the stomach of a crow. Four bits of another apple, weighing an hundred and three grains, were dissolved in little more than fifteen hours. Of

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an hundred and ſeven grains of crumb of wheaten bread, there only remained eleven in the ſpace of thirteen hours.

LXV. From vegetable I proceeded to animal ſubſtances. The eagerneſs which crows ſhew for theſe afforded a certain preſage, that they would be diſſolved within the tubes. I filled eight tubes with beef, and gave them to four crows, two to each. The fleſh was not bruiſed ſmall, as in the caſe of gallinaceous fowls (XLII), but each tube contained a whole piece. An hour had ſcarce elapſed when one was thrown up. The fleſh, upon examination, did not appear to be ſenſibly diminiſhed, but it was thoroughly ſoaked in the gaſtric liquor. The juice was a little bitter, and of a yellowiſh green colour; the fleſh had acquired the ſame taſte and colour in ſeveral places. In an hour and three quarters two other tubes were vomited up; and now the fleſh began to ſhew marks of ſolution. The red colour was changed to a dark cineritious hue, and the whole ſurface was become flabby, and the cohesion of the parts was deſtroyed. In another tube, diſcharged in two hours and an half, the ſolution had made a greater progreſs. A dark covering of jelly ſurrounded the fleſh, which on being touched, adhered to the fingers; and when applied to the

tongue, hardly exhibited the flavour of flesh. The solution had proceeded still further in four hours, when two other tubes were thrown up; in which the flesh did not amount to half the original quantity. The remainder was surrounded by the same gelatinous covering, under which it preserved its natural colour, fibrous structure and savour. There remained only two tubes, which were vomited up seven hours after they had been taken. Both were empty, the flesh therefore had been completely dissolved, except a few bits of jelly that adhered to the inside. I never could perceive the smallest token of putrefaction either during the progress, or at the completion of the solution. And this observation, that I may not be under the necessity of repeating it continually, is to be extended to all the solutions performed not only by other crows, but by all the animals that I shall have occasion to mention in this work; for I can assert with the utmost confidence, that I have never been sensible of the slightest stench either in flesh or any other substance which I introduced in tubes or any other way.

Nothing could be more satisfactory than the information obtained from this experiment. It not only rigorously demonstrates, that the gastric liquor of crows is the solvent

of

of fleſh incloſed in tubes without borrowing the leaſt aid from trituration, but it throws ſtill ſtronger light upon the mode of operation of this menſtruum in the gallinaceous claſs. It begins by ſoftening the texture and altering the colour; next ſucceeds the de-compoſition of the parts; this tranſmutes the fleſh into a kind of jelly of a taſte different from that of fleſh: the jelly is then more thoroughly penetrated by the juice and extracted out of the tubes, and in the ſtomach it is changed into chyle. It appears alſo, that this fluid does not penetrate deeply into the fleſh, but acts on the ſurface only, diſſolving and removing one layer at a time, if we may ſo ſpeak, like other corroding menſtrua, until it comes to the innermoſt part, which it alſo ſoftens and melts.

LXVI. We have ſeen, that the fleſh in the tubes ſhewed no ſign of ſolution till an hour and three quarters had elapſed, and that this proceſs was completed at the end of ſeven hours (LXV). But are we to conclude, that this is the meaſure of the time required by the gaſtric liquor for this operation? or that it would have been accompliſhed in a ſhorter time, if the liquor had had free acceſs to the fleſh? for it is certain, that the tubes are no ſmall impediment to the gaſtric juice. What

then would happen if the impediment was in part removed? and what when it is entirely taken away, by putting the fleſh looſe into the ſtomach? In order to ſolve the firſt of theſe intereſting queſtions, I enlarged the perforations in the ſides of the tubes as much as poſſible (VII), then filled them with beef, as before (LXV), and introduced them into the ſtomachs of ſeveral crows. I now had the pleaſure to perceive the ſuperior efficacy of the gaſtric liquor. In an hour and an half three of the tubes were thrown up, and above a fourth of the fleſh appeared to be waſted. Two other tubes were diſcharged in leſs than two hours, and contained little more than half of their original quantity. And before the completion of the fourth hour, the remaining tubes were entirely empty.

LXVII. Before I proceeded to the other queſtion, I thought of inverting the foregoing experiment (LXVI), and inſtead of allowing freer acceſs to the gaſtric juice, of impeding it more and more, and at laſt hindering it almoſt entirely. I began with employing the uſual tubes wrapped in cloth; this, although it was thin, was ſufficient to prevent the ſolution of the fleſh, which now did not begin to take place till three hours after the tubes were introduced into the ſtomach,

mach, and was not completed till ten had elapſed.

The linen in which the tubes had been wrapped was ſingle: I now doubled it in order more effectually, to hinder the ingreſs of the liquor, and repeated the experiment in the ſame manner. The fleſh ſhewed no token of ſolution for four hours, and was not entirely diſſolved for a whole day.

Upon wrapping round another fold the ſolution did not begin for nine hours, and in the ſpace of a day the fleſh was ſcarce half conſumed. In other reſpects the gaſtric juice had acted upon the fleſh juſt as it does in open tubes, excepting only the ſlowneſs of its operation. It was become externally gelatinous, and incoherent in its parts. It was tinged yellow in ſeveral places; the taſte and ſmell at the ſurface were not different from thoſe of the gaſtric liquor.

I concluded theſe experiments, by trying what would be the effect of putting fleſh into tubes with only three or four holes. After they had continued nine hours in the ſtomach, the reſult was as follows: ſmall excavations of greater or leſs depth were made in the parts oppoſite to the pores, and from theſe excavations ſmall furrows wandered irregularly along the ſurface of the fleſh. The fleſhy

fibres both in the cavities and furrows were become exceedingly tender, they had besides lost their red colour, and were turned yellow. The rest of the flesh was unaltered. From what has been said before, the origin of the cavities and furrows evidently appears to have been derived from the gastric juice, which by insinuating itself through the little perforations, had there dissolved and destroyed the flesh; the rest remained entire, because none of the juice could enter, if we except a very slender stream, which had produced the furrows.

LXVIII. Let us now proceed to the second question and examine how much more readily flesh lying loose in the stomach is digested than when it is enclosed in tubes. Taking some of the same kind of flesh that had been used before, viz. beef, I parted it into two equal portions, one of which was again divided into smaller bits before it was put into the tubes, while the other was left entire. Each portion weighed eleven pennyweights. I next gave the tubes, which were eight in number, to a crow, and to another bird of the same species, equally healthy and robust, I gave at the same time the whole portion of flesh, to which I had previously fastened a thread. This thread, hanging out of the bird's mouth, and

and being wrapped round the neck, I could draw up and examine the flesh at pleasure. And that every circumstance might be alike, I had taken care that the two crows should have their stomachs empty. In thirty-six minutes one of the tubes was vomited, and at the same instant I drew up the flesh from the stomach of the other crow. The latter was throughly imbibed with gastric juice, especially the part that rested upon the bottom of the stomach. It had lost its redness, and was now of a dirty colour; it weighed forty-two grains less than at first; on the contrary, the flesh enclosed in the tube retained its original weight.

The tube and the flesh tied to the string, were replaced in their respective situations; and in order that both might remain the same length of time in the stomach, I took care to return the tubes as they were thrown up. The flesh was entirely dissolved in three hours, when I immediately killed the crow that had the tubes. Upon collecting and weighing all the flesh that remained in them, I found it to amount to about seven pennyweights. Hence in three hours and nine minutes it had lost four pennyweights.

On the other hand, the flesh tied to the string was reduced to half a pennyweight, which

which conſiſted of a packet of membranous or cellular fibres, the fleſhy part having been entirely diſſolved. This experiment clearly ſhews, that fleſh left looſe in the ſtomach is more ſpeedily digeſted than when it is encloſed in tubes. And theory perfectly agrees with fact; for ſince ſolution is the effect of the gaſtric fluid, it is evident that the food, when looſe in the ſtomach, is attacked by a larger quantity than when defended by the tubes.

LXIX. Young crows, as well as all other young birds, eat more than the adult; hence I ſuſpected their digeſtion to be quicker. Having a neſt of the grey ſpecies brought me in June, I made, among others, the experiment related in the laſt paragraph. The reſult was very ſatisfactory. A quarter of an ounce of beef, faſtened as before, to a thread, had ſcarce touched the ſtomach, when the ſolution began, and in forty-three minutes was completed; but an equal quantity diſtributed in ſeveral tubes, required four hours and a half to be diſſolved. Upon opening the ſtomachs of the two young birds, I immediately perceived the cauſe of this rapid ſolution; they contained half a ſpoonful of gaſtric fluid; a quantity ſeldom met with in the ſtomach of adult crows. As the neſtlings require more food, Nature has furniſhed

them

hem with the means of an eaſier and more ſpeedy digeſtion.

It is ſcarce neceſſary to remark, that the experiments related in the LVth and following paragraphs, clearly evince this important truth, that the digeſtion of food is proportional to the quantity of gaſtric juice acting upon it. When this liquor comes in contact only with a few points, the decompoſition is very ſlow and inconſiderable (LXVII); when freer acceſs is allowed, the ſolution takes place more ſpeedily, and is more conſiderable (LXV, LXVI); it is very rapid, when every obſtacle is removed, and the food is on all ſides expoſed to the action of the ſolvent liquor, (LXVIII, LXIX).

LXX. It is a queſtion of ancient date, and ſtill agitated by modern phyſiologiſts, whether certain carnivorous animals are capable of digeſting bone. Among the various points, which I propoſed to diſcuſs in the preſent work, I conceived that this well deſerved the reflection and attention of the philoſopher; I ſhall therefore both here, and in another part of my work, relate what I have obſerved on the ſubject. If we obſerve a crow and a bird of prey devouring an animal, we may be diſpoſed to think that the latter has the power of diſſolving bone, but not the former.

When,

When, for inſtance, a hawk takes a pigeon, it firſt ſtrips the back, and devours the muſcular part of the breaſt; then proceeds to the entrails; and, laſtly, ſwallows the ribs, vertebræ and head, not even ſparing the feet and wings, if it ſhould happen to be very hungry. When the ſame bird is given to a crow, it ſets about ſtripping off the fleſh; but when it has picked this clean, it leaves the ſkeleton. This rejection of the bones, is however very far from being an indubitable proof, in the eſtimation of the philoſopher, that they are incapable of digeſting them. At moſt it inclines us to believe it probable; but ſuch probability requires to be confirmed by facts: and being engaged in enquiries of this nature, I could conveniently bring the queſtion to the teſt of experiment. As I happened to be provided with ſome phalanges of the human toes, I encloſed two in one of the uſual tubes, which remained thirteen hours in the ſtomach. They weighed fifteen pennyweights at firſt; nor was this weight at all diminiſhed, or the bones in the leaſt ſoftened. Being in doubt whether the two great thickneſs of theſe bones might not have prevented the gaſtric juice from acting upon them, I had recourſe to ſmaller ones. Happening one day to find one of my crows dead in the

apart-

apartment where I kept them, and the reſt aſſembled round the carcaſe in crouds, and devouring it eagerly, I took one of the tibiæ, broke it in two, and encloſed it in a tube. The tube continued a whole day in the ſtomach of another crow, but the bone was neither ſoftened, nor diminiſhed in weight. The ſame thing was alſo obſervable, after the bone had been left looſe in the ſtomach for fourteen hours longer.

LXXI. The greedineſs with which the crows devoured their companion, induces me to digreſs, for the ſake of noticing a miſtake of the celebrated Dr. Cheyne. He pretends, that crows cannot digeſt the fleſh of their own ſpecies; and that when they happen to ſwallow it, they vomit it up again. "Ipſa Cornix (ſays Haller, on the authority of Cheyne) cornicis canem ingeſtam non poteſt coquere & deglutitam vomitu rejicit (*a*)." But the truth is, that the fleſh which my crows devoured agreed very well with them, nor did they throw any of it up again. Further, in order to determine certainly whether the above-mentioned writer had fallen into a miſtake or not, I killed and plucked another crow, and threw it into the chamber where

(*a*) Phiſiol. T. 6.

its

its companions were kept, when they immediately leaped upon it, and devoured it with the ſame avidity as they had done the other, without afterwards vomiting the leaſt particle of it. Upon killing and opening, three hours afterwards, one which appeared to have loaded its ſtomach more than any of the reſt, I found the fleſh partly diſſolved, and in the form of a ſemifluid pulp, and partly in the proceſs of ſolution, the very ſtate in which I had ſeen other fleſh.

LXXII. But let us return to bones. It appears that, whether large or ſmall, they are alike inſoluble in the gaſtric juices of crows (LXX). But is this true likewiſe with reſpect to thoſe of a ſoft ſtructure, and which bear ſome reſemblance to cartilage? In order to aſcertain this point, I made uſe of another tibia, taken from an unfledged crow, and which therefore had not acquired its natural rigidity, though it was ſo hard as to break, when I tried to bend it: and now the gaſtric liquor was not inactive. Of fifteen grains, which it weighed at firſt, it had loſt five, after continuing ſix hours in the ſtomach encloſed in a tube. It was become ſo ſoft, that it was capable of being bent into the ſhape of a bow. It continued to waſte and become ſofter; and when it had remained twenty-ſeven

ven hours in the ſtomach, it was ſo much reduced as to reſemble a thin tube of paper. It was not at all gelatinous; and when it was preſſed between the fore-finger and thumb, it ſhewed ſome elaſticity, by recovering its former ſhape when the preſſure was removed. It was not ſcabrous either internally or externally, but had rather acquired a greater degree of ſmoothneſs during its ſolution. In five hours more it had loſt the ſhape of a tube, and was totally reduced to pieces.

LXXIII. I tried other tender bones belonging to larger animals; and more or leſs of them was diſſolved, but with difficulty, and after a very long interval. The ſolution was more ſpeedy in young crows, probably on account of the greater abundance of their gaſtric juices (LXIX).

With reſpect then to the queſtion concerning bones, we muſt conclude that they are indigeſtible by crows, except only ſuch as, on account of their ſoftneſs, are rather to be conſidered as cartilage than bone.

LXXIV. In the preceding, as well as the preſent diſſertation, I have always ſpoken of the ſtomach as the place deſtined for the concoction of the food. And in truth, whether we conſult antient or modern phyſiologiſts, or conſider my experiments, it will appear ſo clearly

clearly proved, that it would be abſurd to entertain a doubt of it. But it may be proper to enquire whether this operation belongs excluſively to the ſtomach in the birds in queſtion, or is partly carried on in the œſophagus. This enquiry is ſuggeſted upon the manifeſt decompoſition, which has been obſerved in part of the food that is found in the œſophagus of ſome animals, as among others in the ſea-crow and the pike (*a*). In order therefore to aſcertain this point, I was led to make a few experiments, which I ſhall relate after I have given a ſhort deſcription of the œſophagus and ſtomach in crows, and of the ſources of the reſpective liquors in theſe two cavities.

LXXV. The œſophagus is membranous, and has no craw. When dilated it is cylindrical, if we except a ſlight contraction in the middle. To the naked eye it would ſeem deſtitute of follicular glands, which however become conſpicuous when it is viewed with a glaſs. They are in ſuch abundance, that there is not a ſingle point of this canal without numbers of them. The excretory ducts are ſcarce diſcernable, though they emit the liquor of the follicles in great plenty. To ſee

(*a*) Helvetius Mem. de l'Acad. 1719. Plot Nat. Hiſt. of Staffordſhire.

this,

this, it is ſufficient to paſs the finger over them. The liquor is of a viſcid nature, of a cineritious white colour, and ſomewhat ſweetiſh to the taſte.

The inferior part of the œſophagus has the ſame kind of fleſhy faſcia that has been noticed in birds with muſcular ſtomachs. This faſcia in crows is ſcarce an inch long; and in them too, as well as in the claſs of birds juſt mentioned, is a tiſſue of large follicular glands very evident to the naked eye, of a roundiſh figure, and full of a ſweet fluid, leſs viſcid than that in the ſmall follicles in the membranous part of the œſophagus, but more denſe, and of a lighter cineritious hue.

LXXVI. In the gallinaceous tribe we have ſpoken of three coats, the cartilaginous, nervous, and muſcular (XLVIII, XLIX), which principally compoſe the ſtomach. Theſe three coats are likewiſe found in birds with an intermediate ſtomach. When the cartilaginous is ſeparated from the nervous coat, and the latter is viewed with the naked eye, it appears to contain a multitude of whitiſh little bodies inchaſed in it, which have the appearance of points; but when examined by the microſcope, change their appearance to that of follicular glands, much ſmaller than thoſe in the fleſhy faſcia (LXXV); theſe fol-

licles are full of a viſcid liquor, which they diſcharge at the extremity towards the ſtomach, when they are preſſed by the finger, or any other body. The diſcovery of theſe glands in the nervous coat having led me to imagine, that they might empty their contents into the ſtomach, I examined the cartilaginous coat with great attention, in order to try if I could find any minute pores for the tranſmiſſion of the liquor into the cavity of that viſcus; but I acknowledge ingenuouſly, that I could not diſcover any. This however by no means proves their non-exiſtence; for they may be ſo ſmall as to elude the ſight, even when aided by the microſcope. And I cannot but believe, that theſe follicles, of which the excretory ducts are turned towards the ſtomach, are deſtined by nature for pouring their contents into that organ.

LXXVII. I now proceed to enquire whether, excluſively of the ſtomach, digeſtion is at all performed in the œſophagus of crows. In order to determine this, I firmly fixed to an iron wire two equal pieces of veal, one of them to the end of the wire, and the other two inches above. I then forced it down the throat of an hungry unfledged crow; the piece faſtened to the end lay in the ſtomach, while the other occupied the œſophagus.

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To prevent them being thrown up, a ſtring was faſtened to the upper end of the wire, brought out at the mouth, and tied round the beak. Thus I was enabled to draw up the fleſh at pleaſure, and examine how much it was diſſolved. In an hour the piece that lay in the ſtomach was quite conſumed, except a little cellular ſubſtance; but the other piece was entire. It was again introduced into the œſophagus, and re-examined an hour afterwards; but now the œſophageal liquor had begun to act upon the fleſh: its weight at firſt was ſix pennyweights, but now only five and a half. It was kept upon the whole ſix hours in the œſophagus, and loſt nearly two pennyweights. Theſe experiments will not permit me to refuſe to the œſophagus all power of digeſtion, an effect undoubtedly produced by the fluid of the follicles (LXXV); but it is inconſiderable when compared with that of the ſtomach, ſince this viſcus diſſolved ſix pennyweights of fleſh in an hour, while the œſophagus diſſolved but two in ſix hours.

LXXVIII. The experiments I afterwards made on young crows were ſtill more deciſive. The ſame wire was employed, and two bits of fleſh were faſtened to it juſt in the ſame manner, the one lying in the ſtomach, the

other in the œſophagus. The former piece was generally quite diſſolved before the ſolution of the other began, though in time this alſo was very ſenſibly waſted. This diminution upon one occaſion amounted to five pennyweights in the ſpace of thirteen hours.

LXXIX. Laſtly, in order to determine whether it was part only of the œſophagus or the whole of that canal in crows which poſſeſſes the power of ſolution, I formed a cylinder of fleſh half an inch thick, and of the length of the œſophagus and ſtomach taken together. I faſtened this cylinder longitudinally to the wire employed before, and forced it down the throat of a crow, ſo that one end touched the bottom of the ſtomach, and the other reached almoſt to the mouth. In a quarter of an hour the whole circumference of the cylinder was imbibed with a fluid, but at the lower end only, which reſted upon the bottom of the ſtomach had the fleſh begun to be diſſolved; here it was become whitiſh. In about an hour for near an inch, i. e. for the whole length of the ſtomach, ſcarce any of the cylinder was left; and what little remained was gelatinous and had loſt its coheſion, while the portion that lay in the œſophagus appeared to be unchanged: but it did not continue ſo; a ſort of eroſion began to take place along the cylinder,

cylinder, and continued but with extreme ſlowneſs. And as this eroſion extended along the whole length of the cylinder, I had reaſon to believe the whole length of the canal capable of concocting the food in a ſmall degree, whenever it happened to be lodged there for ſeveral hours. But ſuch an event never happens when crows take their food at pleaſure, ſince the pieces never exceed the length of the ſtomach. In this reſpect they differ from ſome other animals, in which the food, after they have ſwallowed it, reaches into the œſophagus.

LXXX. Upon conſidering the great quantity of fluid continually dropping into the craw of gallinaceous fowls (LII), it appeared highly probable, that the concoction of the food is not a little promoted by the ſtay it makes there before it falls into the ſtomach. But the fact is juſt the reverſe. The aliment is indeed ſoftened and macerated (LII), but I could never perceive that it was at all diſſolved: at leaſt, I could never ſee any trace of ſolution on ſeveral vegetable matters, which had been long retained in the craw. In a ſpace more or leſs ſhort they become ſoft, and are imbibed with a fluid; but I have not been able to perceive, that they were in the leaſt diſſolved. We muſt therefore conclude, that

the œſophageal liquor in gallinaceous fowls is different from that of crows.

LXXXI. But why is the food ſo ſoon digeſted in the ſtomach, and ſo ſlowly in the œſophagus? Is it becauſe the gaſtric fluid is more efficacious, or in greater quantity, than the œſophageal? What are the properties and characteriſtic marks of theſe two liquors? May we hope that experiments out of the body will be as inſtructive as thoſe made in it? To enable myſelf to procure a large quantity of theſe fluids at pleaſure, was the firſt ſtep towards the ſolution of theſe problems. And as ſuch a quantity could not be eaſily got by killing the birds, it became neceſſary to invent a contrivance for obtaining it from them alive. To put bits of dry ſpunge into the tubes, and leave them ſome time in the œſophagus and ſtomach, appeared to be the beſt means of attaining this end; for they muſt neceſſarily be ſaturated with the liquor of theſe cavities, and when vomited or drawn up, will ſupply the experimenter with a conſiderable quantity, provided he uſes a number. Three tubes were introduced into the ſtomach of a crow, and four hours afterwards vomited up; the three little ſpunges, when they were taken out and preſſed between the fingers, afforded thirty-ſeven grains of gaſtric liquor,

liquor, which was frothy, of a turbid yellow colour, had an intermediate taſte between bitter and ſalt, and being ſet to ſtand in a watch-glaſs, depoſited in a few hours a copious ſediment. As the ſediment appeared to ariſe from the food that was diſſolved by the gaſtric juice (for the bird had taken food a little before it ſwallowed the tubes) I repeated the experiment upon another crow, of which the ſtomach was empty, and continued ſo till the tubes were thrown up. This precaution I ever afterwards obſerved, at the ſame time taking care, that the faſt did not laſt too long, leſt it ſhould induce a morbid ſtate in the animal. I was likewiſe careful to cleanſe the ſpunges from every impurity, by repeated waſhings and dryings, before I made uſe of them again. Upon repeating, with theſe precautions, the foregoing experiment with the three tubes, I obtained thirty-three grains of gaſtric juice in a ſtate of purity. It differed from the former in being of a tranſparent yellow colour, and in depoſiting very little ſediment; it had the ſame bitter and ſalt taſte. It appeared to have very little volatility, as it was kept ſeveral days in a watch glaſs without ſuffering almoſt any diminution. When thrown upon burning coals, it extinguiſhed them inſtead of taking fire; and when brought

near a candle, it did not riſe in flame. Further, paper ſoaked in it and thrown upon the fire, did not burn till the gaſtric fluid was evaporated. Nor had it more volatility or inflammability when juſt taken from the ſtomach and ſtill warm.

LXXXII. The quantity, which was not inconſiderable, obtained from three ſpunges, gave me hopes of collecting enough for chemical experiments at large, and for attempting artificial digeſtion. Every crow was capable, as I found upon trial, of taking eight inſtead of three tubes; and as they would be thrown up in a few hours, I could repeat the experiment ſeveral times a day. Therefore to five crows, of which I then happened to be in poſſeſſion, I gave forty tubes furniſhed with little ſpunges, i. e. eight to each. In three hours and a half all the tubes were returned by the mouth, and the quantity of gaſtric fluid expreſſed from them amounted to four hundred and eighty-one grains. In a few days before I had collected thirteen ounces of liquor. I employed it for the purpoſes for which I had deſigned it, and which ſhall be mentioned in their proper place.

LXXXIII. While I was engaged in theſe experiments, I obſerved ſeveral remarkable facts. The firſt was, that the gaſtric juice flowed

flowed in great abundance into the cavity of the ſtomach; it ſometimes happened, that one of the ſpunges was brought up in a quarter of an hour after it had been ſwallowed, and in this ſhort ſpace it was conſiderably loaded, and in an hour as much as it could be. Secondly, when a conſiderable quantity of fluid has been obtained, another, and even a third may be got immediately. Sometimes when a crow has vomited up the eight tubes, I put freſh ſpunges into them and returned them without delay; and this I repeated a third time and found, that the quantity procured the laſt time was as great as the ſecond, and even the firſt. Thirdly, the fluid had always the qualities above-mentioned (LXXXI), if we except a difference of colour. It is commonly of a pale orange, but ſometimes of a cineritious yellow.

LXXXIV. I took the ſame method to procure the œſophageal liquor, with the variation only of a ſingle circumſtance. The tubes were now faſtened to threads, which were brought out at the mouth, and tied round the beak to prevent its being opened.

Thus the tubes were fixed in the œſophagus, without the leaſt danger of their getting into the ſtomach, or being thrown up. Beſides, I could draw them up at pleaſure. I intro-

introduced four tubes at once into the œſophagus of a crow, and extracted them again in three hours. I learned from this firſt trial, the ſcantineſs of the œſophageal compared with the gaſtric fluid. The four ſpunges ſupplied me with eleven grains only. Doubting whether this might not be accidental, I repeated the experiment ſeveral times, and allowed the tubes to remain longer in the œſophagus, but the ſpunges were very far from being ſo thoroughly ſaturated with fluid as in the ſtomach: ſo that direct experiment proves the great abundance of the gaſtric, in compariſon with the œſophageal liquor. If the ſtomach and œſophagus of a crow be laid open longitudinally, the latter will be found to be moiſtened with its proper fluid only, while the former generally affords reception to part of it likewiſe. Theory too, in the preſent caſe, agrees with fact. The natural poſture of crows, and indeed of moſt other birds, is ſuch, that the liquor which oozes out from the internal ſurface of the œſophagus, muſt deſcend to the lower parts from the law of gravity, and thence into the ſtomach. This organ muſt therefore be the receptacle of the œſophageal fluid; but it is more than probable, that it has a peculiar fluid alſo (LXXVI): beſides, we are certain, that the bile

bile is mixed in confiderable quantity with the gaftric juices. I have very frequently found the bottom of the ftomach in crows full of it, and this is the reafon why this juice is always bitter and yellow. Further, upon opening the duodenum longitudinally, I have perceived the yellowifh green veftiges of the bile, which is difcharged into that inteftine at the diftance of at leaft three inches from the pylorus through the cyftic duct, which evidently arifes from the gall-bladder. The conjunction of all thefe liquors, muft produce a quantity of fluid far larger than that which derives its fource from the œfophagus alone. And I doubt not but this is the reafon, why the food is digefted more fpeedily and perfectly in the ftomach than the œfophagus (LXXVII, LXXVIII). Though I fhould alfo fuppofe, that this is in part owing to the greater energy of the gaftric liquor from the admixture of the bile, which never rifes into the œfophagus, as appears from the juice of that canal never being at all yellow or bitter, but nearly infipid and colourlefs.

LXXXV. It remains now for me to relate fome attempts to produce artificial digeftion with the gaftric juices, referving for another opportunity the recital of the chemical experiments made upon that fluid, obtained both from

from crows and other animals, with the view of acquiring as complete a knowledge as possible of its nature and properties. The great abundance I was able to procure from crows, by means of vomiting, gave me the advantage of instituting a greater number of trials, than with that of gallinaceous fowls (LVI, LVII), from which the gastric liquor could not easily be procured without killing them. I first wished to examine the effect of the gastric juices of crows upon flesh, in the open air. It was January, and Reaumur's thermometer placed near the vessel used for the experiment, stood at the fourth and fifth degree (*a*). For greater certainty in these experiments, I established a term of comparison, by employing similar vessels containing the same flesh infused in water. I also took care upon the present as well as other occasions, that the flesh should be completely immersed in the respective liquors, and that the phials should be closed with stopples. For seven days the flesh kept in the gastric juice, and in water continued the same. On the eighth I

(*a*) Wherever the thermometer is mentioned in this work, the same, viz. Reaumur's is to be understood.

N. B. The fourth and fifth degrees of Reaumur's thermometer answer to about forty-two and forty-three and one-fourth of Fahrenheit's.

per-

erceived a ſlight ſolution, for upon agitating oth liquors, ſeveral particles ſeparated from he larger maſs, and fell down to the bottom f the phials. No further progreſs was af- erwards made, and the gaſtric fluid did not eem at all more efficacious than common wa- er; only the fleſh immerſed in the former vas preſerved from putrefaction, but not in he latter.

LXXXVI. In this experiment I had uſed eef; I verified the ſame obſervation upon he more tender fleſh of calves, chickens, nd pigeons, notwithſtanding the heat of the tmoſphere had now raiſed the thermometer o ſeven degrees (*a*). While I was making heſe experiments in the natural temperature f the air, I was employed about others of like nature in a warmer medium, viz. in ſtove, in which the heat varied between 2°(*b*) and temperate. And now the effects roduced by the gaſtric fluid, differed from hoſe produced by water. In the latter the leſh began to be a little diſſolved in two days; his was the effect of incipient putrefaction, s appeared plainly from the fœtid ſmell which egan to be exhaled. The ſmell continued

(*a*) Forty-eight and three fourths of Fahrenheit's.
(*b*) Seventy-nine and a half of Fahrenheit's.

to

to increaſe during the following days, and in a week became intolerable, when the fleſh was reduced to a nauſeous pulp. In the gaſtric juice the ſolution was more rapid, and exhibited very different phænomena; twenty-five hours were ſufficient to decompoſe the fleſh contained in it, and in a little more than two days there remained only a very ſmall morſel entire. Theſe ſolutions never emitted any bad ſmell; whence it is evident, that they did not ariſe from incipient putrefaction, like thoſe in water, but from a more efficacious and a different menſtruum, viz. the gaſtric liquor.

LXXXVII. Being now engaged by different occupations, I was obliged to interrupt theſe experiments, and could not reſume them till the June following; and then taking advantage of the ſeaſon, I expoſed to the ſun two phials filled to a certain height with gaſtric juice from crows, in one of which were immerſed ſeveral pieces of beef, and in the other crumb of wheaten bread. Nine hours of ſunſhine much forwarded the artificial digeſtion, which was the object of enquiry. A good part of the fleſh was reduced to a kind of glue, that when it was handled adhered to the fingers; nothing like fleſh remained in any of the pieces, but the nucleus, which was ſtill

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consistent and fibrous, which two qualities it lost the next day; after having been exposed six hours to the sun the nuclei, like the outside, no longer retained a fibrous structure. In the sun, the heat as well on the first as the second day, was between forty and forty-five (*a*). The gastric liquor produced upon the bread a change analogous to that which the flesh had undergone. It not only lost its white colour and turned grey, but had become viscous, and no longer presented to the eye the appearance, though it retained somewhat of the taste of bread. Of bread as well as flesh immersed in water and exposed to the sun for the same time, there was a perceptible diminution; but it was very superficial and inconsiderable when compared with that produced by the gastric fluid. The bread turned sour, and the flesh became putrid, circumstances that did not take place in the least, in the other phials.

LXXXVIII. Thus a tolerably complete concoction was obtained in the heat of the sun; but it was reasonable to suppose, that it would be still more perfect in the temperature of the stomach. In the preceding dissertation I have

(*a*) An hundred twenty-two, and an hundred thirty-three and one-fourth of Fahrenheit's thermometer.

ob-

observed, that by way of substitute for the natural heat of the animal that furnished gastric liquor for the experiment, I fixed the tubes under my axilla (LVI, LVII); such an expedient was necessary in that case, since glass is incapable of resisting the violent action of the gizzard. But there was now no longer the same danger, and the experiment might be made in the following manner. Several glass tubes six lines long and three in diameter, were hermetically sealed at one end, and at the other bits of flesh were introduced, and then the tube was filled with gastric fluid. It was then very carefully stopped with sealing-wax, and the tubes were forced into the stomachs of several crows. Should digestion now take place it might be properly called artificial, since it must have been effected in close tubes, to which the juices of the stomach could have no access. But I soon found that the wax became soft in the animal heat, and consequently did not keep the tubes closely stopt, as I wished. There was however no difficulty in substituting a firmer cement, which would not be either melted or softened; and with such a cement I repeated the experiment just mentioned, and others of a like nature, which I shall describe hereafter. I prepared two

tubes in this manner; they were given to a crow, and returned by vomiting in an hour and an half. I will not conceal my amazement at finding, that the pieces of flesh inclosed in the tubes were not in the least changed, unless it was in having acquired a blueish red colour. My amazement was still more increased upon observing, that they had undergone no further alteration after remaining four hours longer in the stomach of the same crow, enclosed as before in two sealed tubes. These bits of flesh weighed in all twenty-eight grains; so inconsiderable a quantity would have been dissolved in a few minutes, if it had been loose in the stomach, and in a very few hours, if it had been enclosed in tubes open at the ends.

LXXXIX. Did this unexpected failure arise from the communication between the external air and that within the tubes being cut off, or from a deficiency of gastric fluid, or else for want of the action of the stomach upon the flesh? I considered maturely these conjectural explanations, but they appeared altogether insufficient. With respect to the last, it is repugnant to all those facts which prove the solution of aliment within tubes, open indeed at the ends, and perforated along the sides, but which effectually prevent the

mechanical action of the stomach upon their contents. That the gastric fluid was in too small quantity for the solution of the flesh, is a suspicion unworthy of attention; for the pieces were always covered by it, so that the quantity of fluid must have been greater than that of solid. Lastly, the communication between the external air and that within the tubes being intercepted, cannot in all likelihood be the reason why solution did not take place. In order to determine this certainly, I made the following curious experiment. Having prepared several glass tubes of the length of six inches, I sealed them hermetically at one end, by means of a reverberated flame, and the opposite extremities were drawn out so as to form elongated cones. Through the open end of these cones I poured a quantity of gastric fluid, together with a few small pieces of flesh, which filled two thirds of the wider part of the cone. I then introduced the cones by their basis into the stomachs of some crows, allotting one to each bird; and when they rested upon the bottom of the stomach, their apexes came out at the mouth. To prevent their being thrown up, I used the precautions mentioned in another place (LXXVI). These conical tubes must no doubt have been very incommodious

modious to the animals, but they were exceedingly well adapted to the end I had in view, ſince a free paſſage was allowed for the external air into them. However, notwithſtanding this, the fleſh remained ſeveral hours immerſed in the gaſtric fluid, without ſhewing any ſign of decompoſition.

XC. It is proper to apprize the reader, that when the ſealed tubes, or the cones, were kept long in the ſtomach, as, for inſtance, ten or twelve hours, the fleſh was generally reduced to a dark-coloured gelatinous pulp. But this did not remove my ſurprize at ſeeing ſo ſlow a ſolution in thoſe cloſe receivers, in compariſon with the rapidity of the proceſs in the ſtomach. The gaſtric juice was quite freſh, it was in ſufficient plenty, and the fleſh put in the tubes and cones was expoſed to the ſame degree of heat when it is in immediate contact with the ſides of the ſtomach.

If crows are killed during the proceſs of digeſtion, the bottom of the ſtomach generally abounds in gaſtric juice, which when compared with that expreſſed from the ſpunges, appears to differ a little, being more denſe and bitter, and of a yellow inclining to azure. The juice which is mixed with the food, and occupies the upper parts of the ſtomach, ap-

proaches more to the nature of that with which the ſpunges are imbibed. Having learned from experiment, that digeſtion proceeds moſt rapidly at the bottom of the ſtomach, on account probably of the gaſtric juice being more active and efficacious there from its immediate mixture with the bile, which gives it the yellowiſh azure hue and a bitterer taſte, I preferred this juice to that from the ſpunges, and repeated with it the experiments with the ſealed and conical tubes mentioned in the LXXXVIIIth and LXXXIXth paragraphs. But the event did not anſwer my expectation, no ſolution of the fleſh taking place till ſeveral hours had elapſed.

XCI. Upon comparing the laboratory deſtined by nature for the proceſs of digeſtion, and theſe receivers prepared by art to accompliſh the ſame end, I could diſcover but two circumſtances in which they differed; the fleſh in the veſſels undergoes the action of a fluid which is never renewed; while, on the contrary, in the natural laboratory it is continually ſubjected to the action of freſh juices, inceſſantly ſupplied by an innumerable multitude of follicular glands. Beſides, the gaſtric juices being confined within the cavity of the ſtomach, there is little or no evaporation; whereas, when expoſed to the air, and conſequently

ſequently cooled, they cannot but loſe ſome of their more volatile and active particles by evaporation. Does then the ſlow ſolution of fleſh in cloſe tubes and in cones, depend upon the gaſtric juice being deprived by theſe two cauſes of part of that energy, on which digeſtion depends? I found from experiment, that the former cauſe, at leaſt, the want of renovation had great influence in retarding the ſolution. If, inſtead of perfectly cloſing the tubes, I left a ſmall perforation capable of allowing ingreſs and egreſs to the gaſtric juice, the ſolution of the fleſh took place much ſooner. The ſame thing happened, when, inſtead of leaving the ſame juice in the cones all the while, I was at the pains of changing it ſeveral times. But warmth is another condition abſolutely indiſpenſable for rendering the gaſtric fluid of theſe animals fit for digeſtion. When this liquor is kept in a temperature not more than four or five degrees above the freezing point, its ſolvent power is ſo much impaired, that it does not ſeem more efficacious than common water (LXXXV). This is alſo obſervable at ſeven degrees (*a*) (LXXXVI). In order to render the effects of the gaſtric juice perfectly

(*a*) Forty-ſeven three-fourths of Fahrenheit's thermometer.

ſenſible, a ſtronger heat is requiſite, as from ten to twenty-two degrees (LXXXVI). Still ſolution proceeds very ſlowly; to remedy this the animal heat is neceſſary, viz. about thirty degrees (*a*) (XC). And ſo remarkable is the effect of heat in this particular, that the very liquor, which, for want of being renewed, diſſolves fleſh ſlowly at thirty degrees (XC), effects this very ſpeedily at forty and forty-five degrees (*b*) (LXXXVII).

XCII. Every time I expreſſed the juice from the ſponges, I waſhed them in pure water, which was tinged yellow by the remains. After having made ſo many experiments on the gaſtric fluid in a ſtate of purity, I conceived it might not be altogether without its uſe, to make one with the water in which the ſpunges had been waſhed; with this water I therefore filled a ſmall glaſs phial, which was left expoſed to the ſun, with a piece of fleſh in it, for three days in July. The fleſh (which was mutton) ſhewed ſome ſigns of ſolution. On the third day, there appeared upon the bottom of the phial a quantity of impalpable matter of a cineri-

(*a*) Ninety-five one-half of the ſame.

(*b*) One hundred and twenty-two, and one hundred and thirty-three one-fourth of Fahrenheit's thermometer.

tious

tious colour, conſiſting of particles ſeparated from the fleſh immerſed in the liquor. Notwithſtanding the ſeaſon, as it uſually is in July, was very hot, it had acquired little or no fœtid ſmell; whilſt a ſimilar piece of fleſh, expoſed to the ſun in the ſame manner, but immerſed in water, became intolerably putrid on the ſecond day.

XCIII. But it is time to quit the ſubject of digeſtion in crows, and to proceed to that of herons, the other ſpecies of birds which I propoſed to examine in this diſſertation. The herons upon which my obſervations were made, and which the nomenclators denominate *cineritious*, or *grey* (*a*), muſt certainly be claſſed among birds with intermediate ſtomachs, ſince the ſides of this viſcus have an intermediate thickneſs and ſolidity between membranous and muſcular ſtomachs. When this organ is dilated, it appears about two inches wide, and as many long; its form approaches to that of a cylinder. When opened lengthwiſe, and obſerved internally, it preſents the appearance of rugæ, of which ſome run in a longitudinal, ſome in a tranſverſe, and others in an irregular and oblique direction. The ſides of the ſtomach are co-

(*a*) Linn. Syſt. Nat. T. 1. Bel. Av.

vered with a kind of gelatinous lining, of ſome conſiſtence, but eaſily removed, and of a colour between white and yellow. This lining ſeems organized; and I ſhould be inclined to ſuppoſe, that it is the innermoſt coat of the ſtomach. The nervous coat next preſents itſelf; it is of a whitiſh colour, and moderate thickneſs, but its texture is ſtrong, and it is not eaſily lacerated. When this coat is cleaned and dried with a napkin, and then diſtended, and compreſſed underneath, it is immediately covered with an effuſion of very ſmall and ſcarce viſible drops, which enlarging and approaching towards each other, form at leaſt a thin aqueous covering. And if this be wiped away, and the nervous coat be again diſtended and ſqueezed, another like the firſt will appear; and in like manner a third, a fourth, &c. with this difference only, that the quantity of moiſture is every time diminiſhed. There can be no doubt of this being a portion of the gaſtric fluid, diſcharged directly into the cavity of the ſtomach. I have employed the utmoſt attention in ſearching whether this liquor derives its origin from glands, or any analogous bodies, but could never diſcover either the one or the other; and therefore we muſt ſuppoſe that it is ſecreted by ſmall arteries, which open into the ſtomach,

ſtomach, and depoſit their contents there. After the nervous, we have the muſcular coat, of a red colour, and ſcarce a line in thickneſs. It is compoſed of fleſhy ſtriæ, partly tranſverſe, partly longitudinal. The former appeared to me to occupy the ſurface only, the latter conſtitute the internal ſtrata, and are continued to the termination of this coat. There is alſo another coat, conſiſting of cellular ſubſtance, and this is the laſt of all.

XCIV. The ſtomach always, and eſpecially when empty, contains more or leſs gaſtric fluid, of a bitter taſte, turbid yellow colour, and generally of ſome denſity. The bitterneſs is owing to the bile, which has that taſte, but in an intenſer degree; I have often found it at the bottom of the ſtomach, and in the vicinity of the pylorus. The gall-bladder exceeds an inch in length; its greateſt diameter is of five or ſix lines; in ſhape it reſembles a ſmall egg, of which the ſharp end is inſerted into the liver. Notwithſtanding many careful examinations, I am not certain of having found the cyſtict duct; I however ſuſpect that it perforates the duodenum, at the diſtance of ſix inches from the pylorus; this I collect from a line of an azure-yellow hue, which ariſes from the gall-bladder, and is inſerted into that part of the inteſtine.

XCV. Above

XCV. Above the ſtomach we meet with the ſame kind of fleſhy faſcia, which I have noticed in gallinaceous fowls and crows, (LXVI, XLVII, LXXV). In the grey heron it exceeds an inch in breadth. This faſcia is alſo covered with the ſame gelatinous lining that inveſts the ſtomach (XCIII). Next we find a nervous coat of a finer texture than that of the ſtomach, of which it appears to be a continuation. This coat, when attentively viewed, looks like a ſieve, ſo much is it perforated at every part. The perforations are nothing but the apertures or mouths of ſubjacent follicular glands, occupying almoſt all the inſide of the faſcia, and viſible through it. If the nervous coat be any where compreſſed, a viſcid, cloudy, and, as far as I could judge, inſipid liquor oozes out at theſe pores, and continues to ooze out if the preſſure be continued. The follicles that lie beneath, manifeſtly ſupply this fluid in ſuch abundance. It would be ſuperflous to deſcribe theſe glandular bodies; ſince they exactly reſemble thoſe of crows and gallinaceous fowls; whether we conſider the immenſe number of them, or their poſition, contiguity, ſhape, or colour. When we raiſe this aggregation of follicles, we come to the muſcular coat, which is very thin, and conſiſts of

of ſeveral ſtrata of long and compact fleſhy faſciculi; next to which lies the laſt or external coat, the thinneſt of all, and conſiſting of cellular ſubſtance.

XCVI. The œſophagus is about twelve inches in length, and in breadth one and a half. Its ſhape is nearly cylindrical, but it becomes narrower near the ſtomach. Upon examining it externally with a microſcope, I diſcovered that it was quite full of minute bodies, which are, I ſuppoſe, glandular. When it has been carefully inverted and inflated, and the humidity, which always covers it, has been wiped away, if now we lay hold of one end, and ſqueeze it forcibly, ſo that it ſhall be enlarged in the adjacent parts, the humidity will appear again; and upon repeating the compreſſion, it will be ſeen ſeveral ſucceſſive times, juſt as in the ſtomach, (XCIII); with this difference, however, as I conceive, that the humidity in the ſtomach derives its ſource from ſmall arteries, and in the œſophagus from minute glands, or ſome analogous bodies.

XCVII. It was natural to ſuppoſe that this apparatus of fluids, which are conſtantly trickling into the cavity of the ſtomach and œſophagus of herons, is chiefly deſigned for digeſtion. But the ſmall number which I poſſeſſed,

possessed, and their almost never vomiting, like crows, indigestible bodies, and consequently tubes, did not permit me to make such a series of experiments as I could have wished. I have however been able to make the most essential, of which one consisted in enquiring into the manner of digestion in the stomachs of these birds. For this purpose I had recourse to the tubes, than which I do not believe there are any means better adapted to such enquiries. It is well known that the grey heron feeds on fishes, frogs, water-snakes, and several sorts of aquatic worms and insects. Those in my possession devoured frogs, and especially fishes, with great greediness; and I therefore used them for my experiments. They swallow frogs of a moderate size whole. A whole frog, inclosed in a tin tube, was introduced into the stomach, together with a fish, of bulk nearly equal, included in another tube. In twenty-four hours the heron was killed, and the stomach opened; though the tubes were very thin, they had received no damage, if we except two slight contusions upon one of them; they were so light, that it was not difficult to guess that they no longer contained the same quantity of matter that had been put into them. The little fish was all dissolved, except some of

of the ribs, a few bones of the head, and a bit of the fleſh of the back, which had become ſo tender, that the parts no longer cohered. The frog's ſhape was more eaſily diſtinguiſhable than that of the fiſh; the pulp of the thighs, and even the bone itſelf, was quite deſtroyed; but the ends of the lower, as well as the upper limbs remained. The integuments of the abdomen and thorax were no longer to be found; and the ſubjacent fleſh was become ſo ſoft, that it appeared to have undergone a ſlight boiling. The bones had acquired the ſoftneſs of cartilage. Theſe remains of the frog and fiſh were impregnated with gaſtric fluid, and taſted bitter. The intelligent reader perceives the immediate conſequences of this experiment. In the firſt place the ſtomach of herons acts with ſome force upon the ſubſtances it contains, as we may collect from the ſlight contuſions upon one of the tubes. Secondly, digeſtion, which was in an advanced ſtate in the frog, and quite complete in the fiſh, is not the effect of trituration, but of the gaſtric fluid, which entering in at the open extremity of the tube, or through the holes at the ſides, penetrated the two animals, and by virtue of its ſolvent power, partly conſumed them; but it made greater havock upon the fiſh than the frog, on

on account of its being tenderer. Thirdly, the efficacy of the gastric fluid of the heron is not limited to the solution of soft parts, such as the skin, flesh, &c. but extends to the hardest also, viz. the bones.

XCVIII. Of the last circumstance I wished to obtain greater certainty, by putting bones alone into the tubes. We have already seen that crows are incapable of digesting hard bones, and that they digest such as are tender with difficulty (LXX, LXXII, LXXIII). It was therefore an object of great curiosity to discover what would happen in herons; and it was easy to satisfy this curiosity, by inclosing bones of several sorts in the tubes; in one I therefore enclosed only the tender bones of frogs or fishes; in another hard bones, viz. the thigh-bone of a turkey broken in two pieces. The pieces of both the hard and tender bones were formed into two bundles, and tied with thread. After an heron had retained these two tubes in its stomach twenty-seven hours, it was killed. It was with a mixture of surprize and pleasure that I saw the tube which contained the fishes and frog's bones empty, while the string remained entire. The gastric juice had then perfectly dissolved the bones. But this was not the case with respect to the contents of the other tube.

tube. I ſhould have conſidered them as untouched, if they had not appeared ſmoother, whiter, and perhaps thinner than at firſt. They now weighed only eleven pennyweights and ſix grains, whereas at firſt they had weighed fourteen pennyweights; they had therefore loſt of their original weight three pennyweights within ſix grains. If this experiment be compared with that made upon crows, with the ſame intention, it will appear evident, that the gaſtric juice of the latter is leſs efficacious in diſſolving bones than that of the heron. And in truth, their nature requires that they ſhould digeſt every part of the animals upon which they feed. I gave them ſome frogs, and obſerved their way of eating them; when of a moderate ſize they ſwallow them whole, when very large they ſeparate them into ſeveral portions, and ſwallow them without parting the fleſh from the bones. Since, then, herons do not enjoy the advantage of vomiting up ſubſtances incapable of being digeſted (LXXVII), and the bones of frogs and ſuch animals cannot eaſily be voided at the anus, Nature has wiſely endowed the ſtomach with the power of concocting and aſſimilating bone.

XCIX. It was equally curious and important to enquire, whether the œſophagus of the heron

heron as well as of crows, is capable of performing digeſtion (LXXVII, LXXVIII, LXXIX). The great length of the neck, and conſequently of the œſophagus, is extremely favourable to ſuch an enquiry. For this purpoſe a flead frog was forced half way down this canal with the head downwards, where it was fixed by a ſtring, of which one end was tied round the hind legs, and the other came out of the mouth, and was wrapped round the neck. In this ſituation it remained two hours, and more was effected than I could expect in ſo ſhort a ſpace. The animal was indeed entire, but was become very tender, though the tenderneſs did not penetrate far below the ſurface. This appearance of incipient concoction induced me to puſh the experiment further, that I might ſee how it would terminate. The frog was therefore replaced in its former ſituation, where it continued three hours longer; I then thought it time to examine the animal, and drew up the pack-thread, but nothing came up with it except the hind legs and ribs; the reſt remained in the throat, and an inſtant afterwards I perceived the animal tranſmit it into the ſtomach. I found the legs and thighs half diſſolved, and being very deſirous of knowing what had happened to the other parts

parts of the animal, I determined to kill the heron without delay. The frog was in the ſtomach; the external muſcular fleſh was quite deſtroyed, and what remained entire was eaſily diviſible into ſeveral portions, eſpecially at the articulations. The ſame appearance of decompoſition had taken place, as if it had been macerated in water; but it did not exhibit the ſmalleſt ſign of putrefaction.

c. Although experiment thus abundantly evinced a ſenſible concoction in the œſophagus, I had not adverted to one circumſtance, which however deſerved attention, viz. to fix the preciſe loſs which the fleſh underwent in that cavity. I therefore repeated the experiment with this view, but having no frogs in my poſſeſſion, I ſubſtituted ſome fleſh with which I happened to be provided, conſiſting of cow's lungs, to the amount of half an ounce, forty grains. It was drawn out of the œſophagus by means of the pack-thread, after it had remained there thirteen hours, when it had loſt ſeven pennyweights and two grains.

As the œſophagus of the heron is membranous, it is more than probable, that its mechanical action did not concur in producing this effect; it however was proper to prove this by direct experiment, which might

be done by means of the tubes. With them therefore I repeated the experiment which I had before made, in order to determine, whether the œſophagus of the heron is capable of digeſting food. Solution of the fleſh undoubtedly took place within the tubes, and ſo I was convinced, that it did not depend on any motion of the œſophagus, but on the efficacy alone of the fluid which is ſecreted by it.

CI. Another experiment yet remained to be made, whence we might deduce not only the exact diminution of the fleſh, but the proportion between its diminution in the œſophagus and ſtomach; two globular pieces, two-thirds of an ounce each, of cow's lights were introduced, one into the œſophagus, and the other the ſtomach; each remained ſeven hours in its reſpective ſituation, when the heron was killed; the ball from the ſtomach at firſt of the ſize of a walnut, was now no larger than a pea, and weighed only twenty-eight grains. That which had lain in the œſophagus was indeed reduced in bulk, though but very little in compariſon with the other; it had loſt three pennyweights eighteen grains.

Both theſe inſtances gave me an opportunity of remarking, that the juices, whether

of

of the œſophagus or ſtomach, did not ſeem to act by penetrating deeply into the ſubſtance of the fleſh, but by corroding the ſurface; the external layer was firſt diſſolved, and then thoſe that lay beneath in their order. And in reality, when I came to waſh the ball taken from the œſophagus, and wipe away the external gelatinous ſtratum already diſſolved by the œſophageal fluid, the next ſtratum ſhewed the natural fibrous, firm, and red appearance; and when the ball was cut into two hemiſpheres, the inſide ſeemed perfectly ſound, without the ſmalleſt ſign of having been impregnated or touched by that corroſive liquor. The ſame obſervation is applicable to the other ball; for notwithſtanding its great diminution, it was quite ſound within.

I had now but two herons left, and theſe I ſacrificed to the deſire of aſcertaining ſtill further the exceſſively rapid concoction of the ſtomach, compared with that of the œſophagus. And in fact, I obſerved it again on two frogs and as many fiſhes, of which the former continued eight hours in the œſophagus and ſtomach, and the latter nine hours.

Theſe experiments incontrovertibly prove, that the œſophagus of the heron as well as of the crow, has the privilege of digeſting

any food that may happen to be lodged in it: this privilege extends likewiſe to other animals, as we ſhall ſee in ſome paſſages of the following diſſertations.

CII. The obſervations related in the preſent and the preceding diſſertation, preſent us with various inſtances of agreement and diſagreement in the digeſtion of birds with muſcular and of thoſe with intermediate ſtomachs. Let us here, for the convenience of the reader, collect into one point of view theſe ſcattered traits; they may fix more firmly in the mind all that we have obſerved, whether curious or intereſting, in theſe two claſſes of animals. With reſpect to the traits of reſemblance, they may all be reduced to the relation between the gaſtric fluids. Firſt then it has been proved, that theſe fluids, beſides being alike in colour, are always ſalt and bitter; and that the bitter taſte derives its origin from the bile, which regurgitates through the pylorus into the cavity of the ſtomach. Secondly, theſe fluids are the immediate agents of digeſtion, both in muſcular and intermediate ſtomachs, independently of trituration. Thirdly, In theſe two orders of birds the fluids act in the ſame manner in the ſolution of the food; they firſt ſoften and next convert the ſurface into jelly, then

then produce the ſame effect upon the interior parts, and ſo inſinuating themſelves gradually till it is completely diſſolved. Fourthly, they do not entirely loſe their ſolvent efficacy as ſoon as they are taken out of the ſtomach, provided they are heated to a proper degree, as artificial digeſtion proves. Laſtly, The ſources from which theſe fluids ſpring, are, in great meaſure, the ſame in both claſſes, viz. the follicular glands, with which their organs abound.

CIII. The differences are in part reducible to the inferior efficacy of the gaſtric fluid in muſcular to that of the ſame fluid in intermediate ſtomachs. Thus the gaſtric fluid in the former is incapable of diſſolving the ſame aliment, which in the latter it eaſily diſſolves. In like manner the food, which each kind of gaſtric juice decompoſes and digeſts, is ſooner ſubject to this change from that which belongs to intermediate ſtomachs. And this is alſo the reaſon, why artificial digeſtion ſucceeds much ſooner with the firſt than the ſecond. The ſame inefficacy that the gaſtric juices of birds with muſcular ſtomachs ſhew in decompoſing certain aliments of a firm texture, extends alſo to their œſophageal juices in decompoſing ſoft ſubſtances, notwithſtanding the latter are tolerably well de-

composed by the œsophageal juice of birds with intermediate stomachs. The prodigious effects of trituration in muscular stomachs, constitute another very striking difference between these two classes of birds, the feeble force of intermediate stomachs being scarce comparable with the enormous power of the other kind. Such a degree of force was absolutely necessary in these, since the juices are incapable of decomposing food of considerable firmness, such as seeds, the natural food of birds provided with gizzards; and therefore an agent capable of breaking, triturating, and thus pre-disposing them for digestion became necessary; and such are in reality the gastric muscles in these fowls.

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DISSERTATION III.

CONCERNING DIGESTION IN ANIMALS WITH MEMBRANOUS STOMACHS. FROGS. NEWTS. EARTH AND WATER-SNAKES. VIPERS. FISHES. SHEEP. THE OX. THE HORSE.

TO examine at full length the nature of digeſtion is the object of theſe diſſertations. By extending my enquiries to the three claſſes to which all animated beings may be referred, I hope to be enabled to ſolve the problem in a ſatisfactory manner. Of theſe claſſes the firſt comprehends animals with muſcular, the ſecond with intermediate, and the third with membranous ſtomachs. The laſt claſs is infinitely more numerous than the two former. If we ſuffer our imagination to range over the immenſe multitudes of quadrupeds, fiſh, reptiles, birds of prey, not even excluding man himſelf, we

ſhall find, that they are all, or nearly all, endowed with membranous ſtomachs; not to mention that numberleſs tribe of minute beings, the greater part of inſects. My taſk would have been endleſs if I had projected enquiries, I will not ſay concerning every ſpecies of animals included under theſe genera, a project which many academies would not be able to execute, much leſs a ſingle obſerver; but concerning great part of them. I was therefore obliged to confine myſelf to reſearches upon a ſmall number. Theſe reſearches combined with others already related in the two firſt diſſertations, will be ſufficient, if I am not very much miſtaken, to ſet the theory of digeſtion in a clear point of view, both in animals and man. As the various ſpecies, which I take into conſideration, cannot be all exhauſted in a ſingle diſſertation, I ſhall diſtribute them into ſeveral, beginning with the animals that are ſituated loweſt in the ſcale of ſentient beings, and ending with that which occupies the higheſt and nobleſt place, with man.

CV. Let us begin then with frogs and water newts, two ſpecies of ſmall carnivorous animals. As the mouth and œſophagus in the former are large, it was eaſy to introduce tubes into their long ſtomachs. But I was ſoon

ſoon aware, that it would be neceſſary to make experiments upon a great number at once, if I wiſhed to know what changes the fleſh encloſed within the tubes underwent in the courſe of ſeveral days; for the tubes were very often vomited up, and at uncertain intervals, ſometimes in a few, ſometimes in ſeveral hours after they had been ſwallowed; at others again, after a whole day, and in ſome inſtances, after a ſtill longer interval. As I knew, that this ſpecies of animal very greedily devours any ſort of fleſh that falls in its way, I did not think of ſelecting, but took what happened to come firſt to my hands, and this proved to be a piece of the ſmall inteſtine of a ſheep, which I divided into twelve portions, and encloſed them in as many tubes. Theſe tubes were diſtributed among ſix of my largeſt frogs, two being given to each. They were kept in a very large veſſel of water with high perpendicular ſides, that they might not make their eſcape. I neglected the tubes that were thrown up, and examined thoſe only which remained in the ſtomach. In the ſpace of a day I obſerved the following reſults. From the intervals of the grating which lay before the open extremities of the tubes, there oozed out a cineritious matter, which,

which, when touched, adhered to the fingers, and formed long filaments. When the grating was removed, I perceived, that this gluten was nothing but the flesh itself, which at that part began to be decomposed and to change its nature, retaining however the characteristic marks of flesh in the more internal parts of the tubes. Upon opening the stomachs I did not find any gastric fluid; they were quite dry.

CVI. In two tubes that were examined at the expiration of two days, the flesh had undergone a further decomposition. It now not only oozed out at the meshes of the lattice-work, but likewise at most of the perforations in the sides of the tubes; and when it was drawn out with the point of a pair of forceps, and then freed by washing from the viscid mucilage, what remained of real flesh or intestine was so very little, that I do not believe it exceeded the thirtieth part of its original weight. At the end of the third day there remained but a single tube in one frog; in this there was no flesh, but it had been all dissolved to gluten, had oozed out of the tube, and adhered to the sides of the stomach, excepting a very small portion that was sticking to the tube. This viscid matter was

was insipid to the taste, a certain proof that the gastric fluid had effected this alteration without the concurrence of any mechanical action of the stomach. It must however be allowed, that this fluid is exceedingly slow in producing its effects, since it required three days. This slowness must have arisen either from the small quantity or inefficacy of the fluid, or perhaps from both causes. In consequence of this tardy action I found in similar experiments upon six other frogs, that the flesh in some of the tubes was not entirely consumed at the end of the fifth day.

CVII. The gastric liquor of frogs is not however on this account incapable of concocting in time substances which we should have supposed above its power, viz. bones. In a quantity of frogs brought me one day by the fishermen, there was one so large, that I was induced by its enormous size to kill it, in order to see what it contained; I found, that the enlarged bulk was owing to a mouse in the cavity of the stomach. The hair had begun to fall off, and the skin was become so very tender, that it had lost its cohesion. The fore as well as the hind legs had undergone a greater degree of solution, the bare bones only being left, and they were considerably wasted

wasted and converted into a semi-gelatinous substance. The mouse upon being opened appeared quite sound internally, the destruction was confined to the surface, and therefore occasioned by the gastric fluid, which had begun to act here on the external parts, just as it does in animals with muscular and intermediate stomachs. The smallness of the extremities permitted the fluid to penetrate them with greater facility, hence it had almost consumed them without sparing even the bones. In this instance I could not perceive any sign of trituration, for the mouse was neither bruised nor lacerated; nor can I conceive what other force can be exerted by stomachs composed of such fine coats, besides that of compressing the bodies they contain, when they happen to be very large.

CVIII. The mouth and throat of water-newts are both so narrow, that they would not admit the usual tubes, they however admitted others made in the same form, but of a smaller size, on purpose for them. From having kept these animals in my house for several years, both when I had occasion to examine the circulation of the blood, and to observe the admirable reproduction of their limbs, I had learned, that the food which they

they devour with the greateſt avidity is living earth-worms (*a*). Nearly the ſame obſervation is made by my illuſtrious friend, Mr. Bonnet, in his fine memoir *concerning the reproduction of the limbs in water-newts*, in which he confirms my diſcovery of this wonderful reproduction in the cleareſt and moſt deciſive manner, after it had been queſtioned by Meſſrs. Adanſon and Bomare, for want of addreſs and ſkill in making experiments in this branch of zoology (*b*). I had then recourſe to earth-worms; they were cut in pieces, and placed alive in the tubes, which were introduced into the ſtomachs of ſeveral ſalamanders. The gaſtric fluid of theſe little reptiles acted more ſpeedily than that of frogs (CVI). The divided worms began to change colour in fifteen hours, and to become ſoft and flabby. About the thirtieth hour the parts had loſt their coheſion, and the

(*a*) I treat at full length of theſe aquatic lizards in my three works intituled,

Prodromo di un' opera da imprimerſi ſopra le riproduzioni animali,

Del Azione del Cuore ne' vaſi ſanguinei,

De' Fenomeni della Circulazione obſervata nel giro univerſale de' vaſi.

(*b*) The memoir is inſerted in Rozier's Journal for November, 1777.

N. B. It is likewiſe reprinted in the late collection of his works.

rings

rings were no longer viſible; and in leſs than two days they were converted into a whitiſh pulp, of which the greateſt part had run out of the tubes.

CIX. The diſſection and examination of the ſtomachs of newts preſented me with a phænomenon, which muſt not be concealed from the reader, both on account of its ſingularity, and the light it throws on the preſent ſubject. This phænomenon is nothing leſs than a great number of ſmall white worms in this viſcus, viſible to the naked eye; of the thickneſs of a thread, and the length (at leaſt in the largeſt) of two-thirds of an inch; however if we wiſh to examine them minutely, we muſt employ the microſcope. They are of two ſorts; in one both extremities terminate in a point, the other has one end pointed; but the other obtuſe, and marked with a dark ſpot; the latter ſpecies is ſhorter than the former, and thinner in the ſame proportion. Each ſpecies is furniſhed with rings, narrower at the ends of the body, and wider at the middle, as is generally the caſe in anular worms. Theſe two ſorts of worms are not flat or compreſſed, but round; it is therefore certain that they do not belong to the genus of *tænia*, or the *gourd-worm*, but to that of round or columnar worms *(teretes)*. They are not looſe in the cavity of the

the ſtomach, as the worms lodged in the inteſtines of larger animals commonly are, but are always found with one extremity inſerted to ſome depth in the internal coat of that organ; hence it requires ſome force to detach them, and frequently they break ſooner than ſeparate. Of thoſe that have the dark ſpot, the more obtuſe end is fixed in the ſtomach; it is impoſſible to ſay whether this is the caſe with reſpect to the others, ſince both ends are equally pointed. The looſe extremity projects into the cavity of the ſtomach, ſometimes coiled up in the form of a circle, and at others twiſted in a ſpiral. If the ſtomach be taken out of the animal, and ſet to macerate in water, the worms live for many hours without quitting their ſituation: if afterwards we ſeparate them with the hand, without breaking them, and place them upon ſome ſubſtance, in order to obſerve their movements, they will be ſeen to writhe in various directions; ſometimes bringing the mouth towards the tail; ſometimes ſtretching themſelves in a right line; and at others making ſtrange contortions, as is uſual with reptiles in general.

CX. Not being able to conjecture for what purpoſe the part perpetually inſerted in the ſubſtance of the viſcus, could be deſigned, unleſs

unleſs it was to ſuck the thinneſt and pureſt part of the liquor; and conſequently ſuppoſing it to be the head of the animal, or at leaſt ſome analogous part, I tried to diſcover the mouth with the aid of the microſcope; but my endeavours were vain. I believe, however, that I found the alimentary canal; it is a bright ſilver-coloured ſpecies of inteſtine, running along the worm, in a tortuous manner, from ſide to ſide; it is always full of a number of particles, which fluctuate regularly, like a buoy, probably impelled by a ſort of periſtaltic and antiperiſtaltic motion. This canal is common to each ſpecies; in that with a dark ſpot at one extremity (CIX), a ſecond canal may be perceived; it is ſtrait, and probably (I ſhould rather ſay certainly) the receptacle for the eggs; for I have always obſerved it more or leſs full of a great number of corpuſcles, of an oval ſhape, floating in a very tranſparent lymph; theſe corpuſcles, when the worm is not in motion, always continue at reſt. If we lay hold of the animal by its extremities, and break it in the middle, the little canal will generally be broken, and the ovula will make their eſcape in a ſtream from the lacerated part. It is not difficult to burſt them between two pieces of talc, when a thin fluid ſprits from them; after

after which the eggs become dry and opake, consisting now of nothing but the empty cover, as always happens to the membranaceous eggs of small animals. Each worm of this species is furnished with those oval particles enclosed in their canal; if they are real eggs, as there is great reason to believe, we must conclude that every individual is an hermaphrodite; it will however remain doubtful whether they are strictly so; i. e. have no need of copulation, like sweet-water polypes, and many other sorts of microscopical animals, &c. or else, in the wider acceptation of the term, are like testaceous and naked snails and earth-worms; each of which brings forth eggs and living young, but requires the concurrence of another individual.

CXI. I might probably be asked whether these worms lodge in healthy newts, or rather in such only as are diseased. This doubt suggested itself to me; and in order to clear it up, I examined not only such as I kept at home, and were therefore liable to the suspicion of unhealthiness, but such also as were newly caught, and full of health and vigour; but the stomachs both of the one and the other harboured alike these unpleasant guests. But it must be observed that they do not fix their abode in all newts; and that in those

where they do, they are not equally numerous. Of the immenſe number I have opened at different times, and with different views, three-fourths have had a family of worms in their ſtomachs; which is ſometimes compoſed of only five or ſix individuals; at others of ſeveral dozens, and at others again of an hundred or more.

CXII. In my numerous examinations of the ſtomachs of the different animals mentioned in this work, crows alone have exhibited a phænomenon nearly reſembling what is found in newts; I mean a quantity of worms lodged in the ſtomach. But theſe worms are not inſerted into the internal coat, as in newts, but are found between the internal and the nervous. We are very well acquainted with the little worms that live in trees, and generally fix their abode between the bark and the wood; and lurking there unſeen, devour the cortical part, which furniſhes them with an agreeable aliment. If the bark ſhould be parted from the trunk on purpoſe, or by accident, their devaſtations are expoſed to view, in the form of excavated paths, winding backwards and forwards in a ſerpentine direction; nor is it uncommon to ſurprize the worms actually employed in forming theſe excavations, which ſerve them at once for food

food and lodging. The ſame thing nearly is obſervable with reſpect to the worms of crows. If the internal be parted from the nervous coat ſlowly and carefully, theſe animals are ſuddenly expoſed to the eye, adhering for the moſt part to the back of the internal coat, lurking in certain cavities formed in its ſubſtance, and which in all likelihood, ariſe from the eroſion of theſe very worms. Further, we find ſome with both ends expoſed, while the middle is deeply buried in the ſubſtance of the internal coat. Laſtly, others have one extremity inſerted into this, and the other into the adjacent nervous coat; but they never make their way into the cavity of the ſtomach. Theſe worms do not appear to differ from thoſe in newts, in colour, length, thickneſs, or in the alimentary canal; they have however one eſſential difference, they are without rings, but have a ſmooth and ſlippery ſkin. In their motions they are dull and languid; when taken from their abode, and placed in water, they live many hours. They are found both in grey crows and rooks; but I have never ſeen them in any part of the body except the ſtomach.

CXIII. But let us return to the worms in newts (CIX, CX, CXI), and conſider them in as far as they relate to digeſtion. I aſſert

that their presence is an incontrovertible proof, that no sensible degree of force is exerted by the stomach; for how is it possible to conceive that the sides of the stomach can rub against each other, or at least impinge against the food, without doing the smallest injury to worms of so delicate structure? I have more than once taken the stomach of a newt between my thumb and finger, and compressed it very gently, or rubbed it lightly, and upon opening it, have always found some rupture, some discontinuation of the parts of these worms. We must therefore conclude, that digestion in water-newts is solely the effect of the gastric fluid, of which the efficacy has been already shewn in the decomposition of earth-worms inclosed in tubes (CVIII). I have also seen its action, in a manner equally striking, on worms which newts have taken and swallowed of their own accord. How tenacious these minute reptiles are of life, is abundantly proved by cutting them into several pieces, in consequence of which they do not die; but on the contrary multiply, as many worms being produced as parts into which they were divided (*a*). It is true, they do not cease to live after having remained

(*a*) See Reaumur, Bonnet, and my Prospectus.

ten

ten or twelve hours in the ſtomach of a newt; nay, when they fill it too full, they void ſome alive and crawling by the mouth, whether by actual vomiting, or whether the worms, after various movements in ſo diſagreeable a place of confinement, at laſt find their way out through the œſophagus. But they certainly die at laſt, not becauſe they are triturated or cruſhed to pieces, for they continue whole for ſeveral hours; the gaſtric fluid firſt ſoftens and then converts them into a gelatinous ſubſtance, and by a continuance of its action, at length reduces them to an impalpable maſs.

CXIV. But how come the tender worms in the ſtomach to eſcape ſolution, when all other inſects, whether aquatic or terreſtrial, upon which the newt feeds, die and are digeſted? If it ſhould be ſaid, that this happens becauſe they have been habituated to the ſtomach by long reſidence, the difficulty would be perhaps removed to a greater diſtance, but certainly not taken away altogether. As the cauſe of this phænomenon, we muſt aſſign the inability of the gaſtric fluid to decompoſe theſe minute beings, however powerful may be its energy upon others of a ſtructure leſs delicate; juſt as a chemical menſtruum is capable of diſſolving one metal, but not another. Thus aqua regia diſſolves

 gold,

gold, but not ſilver; or an acid that combines with the calcareous, has no attraction for the argillaceous and ſiliceous earths. Nearly the ſame difference of digeſtion is alſo obſerved in that of polypes provided with arms; they ſometimes ſwallow their own arms along with inſects; but though the former die and are digeſted, the ſecond do not in the leaſt ſuffer. Thus a polype inſerted into the ſtomach of another polype, continues to live as before (*a*).

cxv. But let us proceed to ſerpents, of which I propoſed to treat after frogs and newts. Thoſe which are moſt eaſily procured in the environs of Pavia are certain terreſtrial ſnakes, called in ſome provinces of Italy, *Smiroldi* (*b*); and water-ſnakes, which many naturaliſts call ſwimming (natrices) (*c*). The firſt conſiderably exceed the natrices and vipers in ſize. The largeſt are about an inch and a half in thickneſs towards the middle of the body, and forty-five and ſometimes fifty inches long. The lower part of the body is white mixed with yellow and green ſtreaks,

(*a*) Trembley, Mem. ſur les polypes.

(*b*) Not deſcribed by Linnæus or any other naturaliſt, as far as I know.

(*c*) *Natrix*. Linn. Syſt. Nat. T. 1. Natrix torquata. Ray. quadr.

the

the upper part is blackiſh, but towards the neck and head interſperſed with a milky white. They fly with greater ſpeed than the water-ſnakes, and far greater than vipers. They are not inferior to the latter in a ſpirit of revenge, and their bite alſo draws blood, as I have myſelf experienced, but is harmleſs. Before I made uſe of the tubes, I wiſhed to acquire ſome knowledge of the œſophagus and ſtomach. Having therefore ſkinned one, and blown up the œſophagus in ſuch a manner that the air could neither paſs out above nor at the pylorus, it appeared to me to reſemble a large inteſtine, cylindrical for about the length of nine inches, and becoming gradually narrower below, ſo as to form a funnel of the length of four inches and an half. I ſoon perceived, that this funnel was the true ſtomach, and the inteſtine the œſophagus. Both the trachea and lungs run along the œſophagus, to which they are firmly attached by means of a membrane, as alſo is the heart, which has the ſhape of an elongated pyramid, ſituated at the origin of the lungs. We find likewiſe a viſcus ariſing from the baſis of the heart, aſcending upwards along the œſophagus, and adhering in great meaſure to the trachea: it is of the ſame length as the lungs, but its ſubſtance is different, being tender

and aſh-coloured; I could not then determine what it was. Next below the lungs lies the liver, which, together with the *vena portarum*, reſembles a long narrow leaf attached to a very long footſtalk; both adhere to the œſophagus. Below the ſtomach we find the ſpleen, nine lines in length and of a very acute oval ſhape. The gall-bladder lies in the region of the ſmall inteſtines, conſequently at a great diſtance from the liver; when we preſs it the duct is filled with bile, which it evidently diſcharges into the duodenum at about the diſtance of an inch from the pylorus. Near the gall-bladder we find another body ſmaller than it, attached to the duodenum, and of a fleſhy conſiſtence. I ſhould ſuppoſe it to be the pancreas.

CXVI. If we ſeparate the œſophagus and ſtomach from the lungs and other parts juſt deſcribed, and open it longitudinally, the œſophagus appears ſimply membranous; the membrane of which it conſiſts is very thin and of a ſilver colour. The ſtomach is compoſed of thicker ſides, and among the coats which compoſe it we have one of fleſh, which like the fleſhy coats of other membranous ſtomachs, is very thin. I could not perceive, that the œſophagus is provided with any glands or follicles; but I obſerved, that the ſtomach

ſtomach was abundantly ſupplied with them throughout its whole length; they diſcharge part of their liquor on being preſſed, and the internal coat is moiſtened with it.

CXVII. I come now to experiments relative to digeſtion. I found great facility, not only in paſſing the tubes into the ſtomach, but likewiſe in bringing them up whenever I pleaſed. I made an aſſiſtant lay faſt hold of the ſnake ſo as to prevent its ſtriking or wreathing round the body, while I opened the mouth and forced a tube in lengthwiſe, and then, by means of a thin rod, thruſt it two or three inches down the throat. After this the reſt followed of courſe; for I had only to preſs with my fore-finger and thumb the neck of the animal in the place oppoſite to the top of the tube, which was forced to deſcend for ſome way down the œſophagus, and by a repetition of the ſame manœuvre I ſoon brought the tube to the bottom of the ſtomach, which I knew by the reſiſtance it made when I attempted to puſh it lower; for now the narrow paſſage of the pylorus prevented its deſcent. By a like preſſure, but made in the oppoſite direction, from below upwards, I could bring up the tube from the ſtomach into the œſophagus, and thence out through the mouth. I employed this con-

trivance

trivance for introducing the tubes into the ſtomach, and bringing them out at the mouth in water-ſnakes likewiſe, and even vipers, managing the laſt however with ſome care, which is very requiſite, in order to avoid being bit by theſe ſerpents during the operation, when they are highly exaſperated.

CXVIII. When I was opening ſome of my land-ſnakes (*ſmiroldi*) to examine the alimentary canal, I found in the ſtomach of one a wall-lizard not in the leaſt injured or digeſted. I thought of employing it for my experiments, as it muſt be a kind of food well adapted to theſe reptiles. I therefore encloſed a piece of the tail of this lizard in a tube, which continued for a whole day in the ſtomach without having its contents at all diſſolved. Thirty-ſix hours produced ſomething more. The tail of the lizard is compoſed of a number of little muſcles, enchaſed one within the other, and bound round by a thin anular membrane. The piece of tail was placed in the tube in ſuch a manner, that the inveſting membrane was in contact with the ſides, and the muſcles were bare at the open ends. The membrane had ſuſtained no injury, but the muſcles were eroded on the plane of ſection, and a little excavated. Upon touching them I found, that they had been

been converted into a gluten of ſome viſcidity. The gaſtric fluid then (for the mechanical action of the ſtomach could produce no effect within the tubes, were any ſuch action to be exerted at all) had begun to digeſt the fleſh, by diſſolving what lay at the ends of the tube before it attacked that which was contiguous to the ſides; not only becauſe it was not covered by the membrane, but alſo becauſe it had freer acceſs at the ends: the ſolution however went on, though very ſlowly; for after the tube had been five days in the ſtomach, a little of the muſcular fleſh remained, and the membrane was almoſt entire.

CXIX. The fleſh of a lizard's tail is rather tough, and it was probable, that this circumſtance had retarded the progreſs of digeſtion; it was therefore proper to employ ſome of a leſs firm texture; accordingly part of the liver of the ſame animal was encloſed in the tube, and given to a ſnake *(ſmiroldo)*. In this inſtance digeſtion was more ſpeedy; for in three days and an half the tube was quite empty.

But what if inſtead of encloſing the fleſh in tubes, we ſhould introduce it into the ſtomach without any covering? It was obvious to ſuppoſe, that it would be ſooner digeſted, ſince the gaſtric juice would have freer ſcope for

for its action. And ſo in reality it happened. A piece of lizard's tail of the ſame ſize as in a preceding experiment (CXVIII), did not require quite two days for its digeſtion; and a portion of liver, equal to that before-mentioned (CXVIII), underwent the ſame proceſs in two and thirty hours. Of this I aſſured myſelf by opening the ſtomachs of the two ſnakes, one of which had taken part of the liver, and the other of the tail.

CXX. We come now to the water-ſnakes or the *natrices*. Nothing can be more ſtriking than the reſemblance between the ſtomach and the œſophagus in this, and the foregoing ſpecies. Beſides the trachea, lungs, heart, liver, vena portarum, having nearly the ſame configuration, and lying on the ſame parts of the œſophagus; this cavity is very capacious and long, conſiſts in like manner of thin membranous coats, and ends in a funnel, which is the true ſtomach of the animal. The gall-bladder too is about an inch diſtant from the lungs, and depoſits its contents in the duodenum, by means of the cyſtic duct. The ſtomach alſo, as we have obſerved in the land-ſnake (*ſmiroldo*), is furniſhed with a great number of follicular glands.

CXXI. It is eaſy to learn the nature of the food of water-ſnakes, and we ought in conſequence

ſequence to provide it for our experiments. Among the antients Oliger Jacobeus, where he treats of frogs, and among the moderns Valiſneri will ſatisfy us, that theſe reptiles live chiefly upon frogs. Next to man water-ſnakes may be denominated their greateſt ſcourge. They particularly frequent the water of ditches, puddles, ponds, lakes, ſuch in ſhort as is frequented by frogs; and here they make an eaſy prey of them, notwithſtanding they mutually give each other notice when they perceive the ſnake at a diſtance, by a kind of whiſtle or outcy of diſtreſs, as I have often obſerved, at which all fly with the utmoſt precipitation: Dante was not acquainted with this circumſtance.

> Come le rane innanzi l'inimica
> Biſcia per l'acqua ſi dileguan tutte,
> Finchè alla terra ciaſcuna s'abbica (*a*).

A fiſherman having brought me three very large and vigorous water-ſnakes, I gave each at the ſame time a tube encloſing a different part of a frog; one muſcle, the other liver, and the third ſpleen. The tubes were left three days and an half in the ſtomach. Upon forcing them out, I obſerved the ſame kind

(*a*) Infern. Cant. 9. Fol. 161, &c. As frogs ſcour along the water, at the approach of the water-ſnake, without ſtopping, till they have gained the dry ground.

of

of digestion that I had before seen in frogs (CV, CVI). The flesh was beginning to be changed into an adhesive cineritious gluten; the interior parts were unaltered. The tubes were now introduced a second time into the stomachs, and when they had continued there two days they were found empty; some of the adhesive matter stuck to the outsides of two of them.

CXXII. It is not unknown to naturalists, that this species of snake has no teeth, and is consequently obliged to swallow its prey whole. In summer I have often taken them with whole frogs in the stomach. It was therefore not unreasonable to suppose, that they are capable of digesting the bones; and the less so, as it seems difficult for them to be voided backwards, on account of the narrowness of the intestines. It might indeed be suspected, that these bones are vomited, as I have found to be the case with the tubes, both in this and the former species; but this is not a constant and regular evacuation, as in crows (LIX) and birds of prey, as we shall see hereafter; but takes place at uncertain intervals, and sometimes does not happen at all for several days. In order however to ascertain the fact, I broke two tibiæ weighing nine grains each to pieces, enclosed them in the tubes,

tubes, and forced them into the ſtomachs of two water-ſnakes. After they had continued there two days, they were become ſoft, and had loſt three grains. In five days more they were ſtill ſofter, and now weighed together only five grains. Soon afterwards the two ſnakes died, and it was not in my power, though I wiſhed it very much, to proſecute this curious experiment as far as it would go. From the beginning however of the progreſs we may ſuppoſe, that the bones would have been totally diſſolved, and conſequently it is highly probable, that water-ſnakes digeſt the bones of thoſe animals upon which they feed.

CXXIII. By the activity of the gaſtric fluid of the water-ſnake in digeſting not only fleſh but bone, I was induced to try to procure a quantity that I might examine it more particularly. For this purpoſe I employed ſpunges as before (LXXXI, LXXXII), and my ſucceſs exceeded my expectations. Six little ſpunges, that had lain two hours in the ſtomachs of three ſnakes, encloſed in tubes, afforded me enough to fill a watch-glaſs of a moderate ſize. It had the following qualities; the colour approached that of ſoot, it had the fluidity of water, and evaporated very ſlowly: it has both a ſalt and bitter taſte, and is not inflam-

inflammable. Hence it appears to bear a very ſtrong reſemblance to the gaſtric fluid of the other animals, upon which my experiments were made: this reſemblance extends likewiſe to the odour, which is exactly like that of the ſame juices in birds of prey, of which I ſhall ſpeak particularly in the next Diſſertation. I reſerve the account of ſome chemical experiments made upon this fluid, till I ſhall have an opportunity of ſpeaking of the examination of the other gaſtric juices which I have already mentioned, or ſhall have occaſion to mention in the preſent work.

CXXIV. We have before ſeen the ſtrong analogy between the configuration of the ſtomach and œſophagus in land and water-ſnakes. In vipers theſe cavities have the ſame general form; nor do they differ with reſpect to the efficient cauſe of digeſtion. I repeated upon them moſt of the experiments deſcribed above: ſeveral tubes, furniſhed with different ſorts of fleſh, were left in their ſtomachs for a ſpace more or leſs long, and the effect was juſt the ſame as in water and land-ſnakes; it would therefore be ſuperfluous to deſcribe them particularly. It will be better to turn the reader's attention to ſome experiments on theſe three ſpecies of reptiles differently

ferently modified, but relative to the same subject.

CXXV. Having frequently opened these animals when newly taken, I have sometimes observed, that their stomachs are not large enough to contain the whole prey, and that part lies in the œsophagus. This part never shewed any mark of concoction, notwithstanding what lay in the cavity of the stomach was sometimes half digested. Thus, for instance, I have found five or six large beetles in the body of a land-snake or viper; those that lay in the stomach were scarce distinguishable, while, on the contrary, those in the œsophagus were entire, or nearly so. I once saw a frog with the lower limbs, which projected out of the stomach, not at all damaged, while the rest of the body lay in the stomach and was half reduced to a pulp. These experiments made by the serpents themselves gave me reason to suppose, that what takes place in them is exactly contrary to what happens in crows and herons, for the reader will remember, that in these birds the œsophagus is really capable of digestion (LXXVII, LXXVIII, LXXIX, XCIX, C); but in the animals in question it seems to belong exclusively to the stomach. A very simple experiment was sufficient to ascertain

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the point. Into the ſtomach of one of theſe ſerpents a frog, for inſtance, might be ſo introduced that part ſhould lie in the œſophagus. The frog might be faſtened to a cylinder of wood, and thus firmly fixed in the ſame place. The cylinder ſhould touch the bottom of the ſtomach with its lower extremity, and reach ſome way above that organ. I applied this apparatus to a water-ſnake, and at the end of the ſixth day opened it longitudinally. Upon examination my ſuſpicion that the œſophagus was without efficacy, was changed into firm perſuaſion. The lower limbs, the part of the animal that had lain in the ſtomach, had nothing left but the bare bones, whereas the whole body which had extended into the œſophagus had ſuffered no injury.

CXXVI. The experiments related in the CXVIIth and following paragraphs were made in April, when the animals had lately quitted their ſubterraneous lurking places, and ſtill retained ſomewhat of that torpor which benumbs them during winter. At this time digeſtion, as we have ſeen, is a very ſlow proceſs. Are we to preſume, that when they become more lively, active, and vigourous, as the heat of the ſeaſon increaſes, they likewiſe perform digeſtion more ſpeedily? for the effect

effect of heat in promoting the operation of the gastric fluid appears from other facts (LXXXVII). This idea was suggested by reperusing the fine memoirs of the illustrious Trembley on polypes, from which the influence of the temperature of the atmosphere upon the digestion of these wonderful animals is evident; insomuch, that the very food which in a hot season is completely digested in twelve hours, when it is cold requires sometimes two or three days. In order to determine whether the same thing takes place in my reptiles, I chose July for a term of comparison, when the difference, if any existed, must needs be more striking, as the thermometer in the shade stood at 22° and 23° (*a*); whereas in April, when the first experiments were made, it did not rise above the twelfth or fourteenth deg. (*b*). And now upon repeating the experiments already described, I found that heat has some power in accelerating digestion, but not so much as I had supposed. Flesh inclosed in tubes did not require above two days to be completely digested; and when an equal quantity was in-

(*a*) Eighty-one and an half, and eighty-three and three-fourths, F.

(*b*) Fifty-nine, and sixty-three and an half, F.

troduced into the ſtomach by itſelf, about half that time was ſufficient.

CXXVII. Naturaliſts were already apprized of the tardineſs of digeſtion in ſerpents. In Bomare we read an account of a ſerpent at Martinico, which retained a chicken in its ſtomach for three months, and did not completely digeſt it, for it ſtill preſerved ſome traces of its ſhape, and the feathers ſtill adhered to the ſkin (*a*). It is a circumſtance deſerving of particular notice, and which I ſhall have occaſion to apply in another place, that fleſh does not become fœtid from remaining long in the ſtomachs of theſe cold animals, as I have obſerved in the courſe of my experiments, and eſpecially in a viper, which having been kept above two months in my houſe, could not but be unhealthy; this individual retained in its ſtomach for ſixteen days a lizard, which had been previouſly macerated in the gaſtric fluid; nor could I perceive that it had any odour, except that of this juice. And yet ſuch was the heat of the ſeaſon, that another lizard, about the ſame ſize, which I had placed out of curioſity in a cloſe veſſel, containing a little water, emitted an inſupportable ſtench before the expiration of the third day.

(*a*) Dict. d'Hiſt. Nat.

CXXVIII.

CXXVIII. But what can be the cauſe of this ſlowneſs of digeſtion in ſerpents? As they are cold animals, that is to ſay, as their blood very little exceeds the temperature of the air, it may ſeem probable that this phænomenon might be owing to the want of that heat, which is peculiar to animals of warm blood. And I ſhould not have been unwilling to admit this cauſe, if other animals, with blood equally cold, had not enjoyed the privilege of digeſting their food in a much ſhorter period, as we ſhall ſoon ſee (CXXXIV). We cannot aſſign a deficiency of gaſtric fluid as the reaſon, for their ſtomachs abound with it (CXXIII). I cannot attribute it to any thing but the inefficacy of the fluid itſelf; and this is by no means ſingular, for we have already diſcovered a circumſtance nearly ſimilar in animals with muſcular ſtomachs, in which the gaſtric juices do not ſo ſoon digeſt the food, as in animals with intermediate ſtomachs (CIII).

CXXIX. Of fiſhes I ſhall firſt treat of that ſpecies which bears ſo ſtrong a reſemblance to ſerpents, and is even conſidered in the chain of animated beings, as the intermediate link between fiſhes and ſerpents, I mean the eel. The ſtomach in this animal varies from the ſtructure generally obſerved by nature; it

is not a canal immediately continued with the duodenum, but a kind of blind gut, of considerable length, ending in a point; after the food has been received into this gut, and been digested, it must ascend, and return to the upper part of the stomach, in order to pass into the duodenum, which forms an acute angle with that upper part. The natural figure of both may be seen in Blasius's Anatomy of Animals (*a*).

Into the stomachs of four eels I introduced several tubes, containing pieces of fish, the food most agreeable to eels. In order to preserve them alive, I turned them into a small stew, whence I could take them at pleasure. They were killed at the end of three days and eighteen hours; and the tubes were found at the bottom of the stomach, entirely covered with a dark-coloured mucus, which, on attentive examination, appeared to be the remains of the fish, that by this time was digested. Upon wiping the tubes, and examining the inside, five out of eight were empty, and the three others contained a bit of flesh of the size of a vetch, but it had lost its cohesion.

CXXX. This experiment abundantly proves, that in this fish digestion is produced by the

(*a*) Plate LII. Fig. I.

gastric

gastric fluid; I therefore proceeded to experiments upon such as are more justly entitled to the appellation of *fishes*. I chose for this purpose carp, barbels, and pikes, as they were the most easy to be procured. It has been long well known that the alimentary canal in many scaly fishes, is provided with one or more blind appendixes, which, because they lie in the vicinity of the pylorus, have been named *pylorici*; they are always full of a white, mucilaginous, and saltish fluid, which is discharged into the canal, and derives its origin from a number of glands lying in the appendixes. In some species they are few, in others in considerable numbers, and in others again exceedingly numerous; they amount in the sturgeon to an hundred; in those species, in which they are most numerous, the several fasciculi meet in a common duct; hence, notwithstanding their numbers, they discharge their contents into the pylorus (*a*) by a few mouths. In the three species I have just mentioned, this singular apparatus is not to be found; but the inside of the stomach and intestines is furnished with yellow bodies, that probably contribute in some way or other to digestion, though I have

(*a*) Haller, El. Phys. T. 6.

not been able to aſcertain their preciſe uſe. At firſt ſight they look like anular worms, adhering, as in newts, to the internal ſurface of the ſtomach (CIX); but if we lay hold of them with the forceps, the anular form vaniſhes, and we find that they are real appendiculi to the ſtomach and inteſtines. When ſtretched out, they are three lines long; each adheres to the villous coat by a footſtalk. If we ſtretch them till they break, a conſiderable quantity of yellow liquor iſſues out, and the body becomes more ſhrivelled; and if it be now removed from the place of its inſertion, we find under it a little tumour, through which a globule is ſeen indiſtinctly; and if the tumour be cautiouſly raiſed, appears diſtinctly: it is of a yellowiſh white colour, from the liquor which it contains. Are theſe globules cluſters of glands, and the vermiform bodies elongated ducts for conveying the liquor into the cavity of the ſtomach? I would very willingly have adopted this notion, if I had not found that theſe ſubſtances, when compreſſed from the lower end upwards, never diſcharge their contents, either from the ſummit, or any other part, contrary to what happens when we ſqueeze the follicular glands in birds with muſcular, intermediate, or membranous ſtomachs. On this

this account I ſuſpend my opinion on the ſubject; although I ſhould incline to ſuppoſe that they are of ſome uſe in digeſtion.

CXXXI. Immediately under the teeth, the very beginning of the œſophagus in the carp is moiſtened with a conſiderable quantity of a whitiſh turbid liquor, of a viſcid conſiſtence, and inſipid taſte, which when wiped off is inſtantly reproduced: and we here find a number of white papillæ, broad at their baſis, and terminating in a point, which, when preſſed, emit the ſame kind of fluid. If we make a gentle preſſure any where near theſe papillæ, a fluid iſſues out, but, as I ſhould ſuppoſe, of a different nature, ſince it is tranſparent, thinner than the former, and not at all viſcid. With the œſophagus, which is very ſhort, and of conſiderable thickneſs, is continued the ſtomach, of a membranous ſtructure, and very thin. It is eaſy to diſtinguiſh two coats in this organ, the internal and the nervous; in the latter are buried thoſe globules, which left me in doubt whether I ought to conſider them as cluſters of glands (CXXX). In this ſhort deſcription, we ſee ſources capable of ſupplying the ſtomach with a large quantity of fluid, notwithſtanding it wants the *pylorical* appendixes.

CXXXII.

CXXXII. The conformation of the ſtomach in the barbel, does not correſpond either with that of the carp, or various other fiſhes. The œſophagus, ſtomach, and inteſtines conſtitute a ſingle gut, nearly as in earth-worms, and a variety of inſects; this gut is only a little dilated at the ſtomach, and contracted at the commencement of the inteſtines. I could not diſcover within this canal any veſtige of glands or analogous bodies. However, both the œſophagus and ſtomach are continually moiſtened with a fluid in great abundance; which when we preſs or dilate either of theſe cavities, is ſeen to tranſude from the internal ſurface; and ſince, according to every appearance, it does not ariſe from glands, we muſt ſuppoſe that it comes from the open extremities of ſmall arteries which terminate here.

CXXXIII. The ſtomach of the pike has the ſhape of a bag or ſack, of much greater length than breadth; it is full of longitudinal rugæ, of a light fleſh colour, and compoſed of coats ſo thin, as to be ſemi-tranſparent. The rugæ extend upwards into the œſophagus, which is eaſily diſtinguiſhed from the ſtomach by its white colour, and greater thickneſs. There is no appearance of glands either in the one

or

or the other, though both, and especially the stomach, abound with liquor.

CXXXIV. As fishes are subject to vomiting, the tubes which I had introduced into the stomachs of my carps, barbels, and pikes, were frequently returned; and I was often chagrined at finding them, after a few hours continuance in the body, at the bottom of the vessel used for keeping them alive. However, from frequently repeating my experiments, though so many tubes were ejected prematurely, a few remained several hours in the stomach; and these were sufficient to satisfy my wishes. In the present case, the same thing happened which I had so often observed in other animals; the flesh was digested within the tubes, and that in a much shorter space than in serpents (CXXVI, CXXVII). This observation was verified on the barbels, carp, and pike; the two latter species exhibited a phænomenon, too closely connected with the present subject to be omitted. Happening one day to open a pike, I found within it a little fish, about three inches in length, lying longitudinally along the stomach, so that the whole head occupied the œsophagus. I had here a clear view of the origin and progress of digestion. The jaws of the small fish retained their natural colour, and appeared unal-

unaltered. The eye was beginning to quit the orbit, and the gills had loſt their purple hue, and were become very ſoft. In the ſtomach the marks of digeſtion were more evident. The fleſh of the body was more and more tender as I proceeded downwards; and towards the bottom it had degenerated into a ſoft and ſhapeleſs maſs. The extremity of the tail, which had lain at the bottom of the ſtomach, was entirely conſumed, and with it the vertebræ of the ſpine, and the adjacent bones.

CXXXV. I met with another ſimilar circumſtance in a little carp. It had ſwallowed a ſmall lamprey, which was ſtretched out at full length, and occupied the whole ſtomach, and at leaſt two thirds of the œſophagus. The part that lay at the bottom of the ſtomach was changed into a kind of mucilage, in which there was no appearance of any thing organized, except ſome of the dorſal vertebræ. The parts that lay higher ſtill cohered, but they came away from the animal on being touched. The others, which occupied the œſophagus, ſhewed likewiſe marks of an incipient concoction.

Nothing can be more inſtructive than theſe two facts combined. They ſhew, in the firſt place, that the bottom of the ſtomach digeſts more

more quickly than the parts ſituated above, as we have ſeen in other animals (XC): ſecondly, that the œſophagus, as well as the ſtomach, is in ſome meaſure capable of concoction, a circumſtance that has been already noticed with reſpect to crows and herons (LXXVII, XCIX, C, CI); and which phyſiologiſts have obſerved before me in other fiſhes. Laſtly, that digeſtion in the œſophagus is ſlower at its beginning, and in its progreſs; two things that have been remarked in the birds juſt mentioned.

With reſpect to the triturating power of the ſtomach in theſe three ſpecies of fiſhes, not to mention that digeſtion has been obtained in the tubes without its concurrence, I am of opinion that it has no exiſtence; this I infer, from no effect being produced by it upon the tubes, upon which I have never perceived the ſmalleſt bruiſe, contuſion, or injury, in my experiments on fiſhes, any more than on frogs, newts, and ſerpents, though they were ſo thin, that the ſlighteſt force would have been more than ſufficient to diſtort or bruiſe them.

CXXXVI. From cold animals let us proceed to ſome experiments on the ſtomachs of warm animals, ſuch as ſheep, oxen and horſes. Reau-

Reaumur, in his ſecond and laſt Memoir (*a*) concerning digeſtion, after relating at length his obſervations on a kite, ſlightly touches on ſome experiments upon dogs and ſheep. I will here quote the reſults of his experiments on the latter ſpecies, reſerving thoſe on the two others for another place. Deſirous of ſeeing whether digeſtion in ſheep is the effect of the gaſtric fluid, he forced down the throat of one of theſe animals four tin tubes, two of which were full of freſh blades of graſs, and the two others of chopped hay. Fourteen hours afterwards the ſheep was killed and opened, when the four tubes were found in the firſt ſtomach, with their contents; and the graſs and hay were not in the ſmalleſt degree digeſted, and but little ſoftened.

Suſpecting that they would undergo further alteration, and be even digeſted by a longer continuance in the ſtomach, Reaumur cauſed eight other tubes to be prepared in the ſame manner, i. e. four to be filled with freſh graſs, and the remaining four with hay. The graſs before it was put into two of theſe tubes, and the hay before it was put into two others, were moiſtened with human ſaliva. All the eight were forced down the throat of a ſheep, which was killed thirty hours afterwards;

(*a*) Hiſt. de l'Acad. Roy. An. 1752.

during

during this interval, the animal had been kept ſtrictly faſting; this precaution had alſo been obſerved with reſpect to the former ſheep, that had not retained the tubes ſo long. In the courſe of the thirty hours, the greater part of the tubes were voided at the anus, but a few remained in the firſt ſtomach.

But neither had the graſs or hay undergone the ſmalleſt degree of digeſtion; they preſerved their original form and dimenſions; and when they were pulled at the two oppoſite extremities, reſiſted efforts to break them with the ſame force that ſimilar pieces of graſs or hay, that had been a little macerated, would have done. Hence it is inferred by this illuſtrious naturaliſt, that digeſtion cannot be effected in the ſtomachs of ſheep by a ſolvent, unleſs that ſolvent be aided by trituration: he was however ingenuous enough to confeſs, that theſe two experiments are of themſelves very far from throwing ſuch light upon the preſent ſubject as he could have wiſhed.

CXXXVII. The firſt thing I undertook with reſpect to ſheep, was to repeat exactly Reaumur's experiments. Thinking the tubes I had hitherto employed too ſmall, I had ſome made eight lines in length, and four in diameter. But I could not at firſt introduce them

them into the ſtomach. After I had put them into the throat with my hand, though I puſhed them as far as my fingers would reach, they were always returned. I was unacquainted with Reaumur's method, for he does not give the leaſt information about it. At laſt an expedient occurred; it conſiſted in putting the tubes, provided with their contents, into a hollow cane, and introducing this cane into the œſophagus; I could now puſh them forwards with a rod, till they dropped out at the lower end of the cane into the œſophagus; and as the part of the œſophagus into which the tubes were now introduced, lay at a great diſtance from the mouth, the animal, in ſpite of all the efforts he made to return them, was obliged to receive them into the ſtomach: to the ſame contrivance I had recourſe likewiſe for oxen and horſes. Six tubes were given to a ſheep; in twenty-ſeven hours it was killed and opened; it had eaten nothing during all the time it retained the tubes; and this precaution was ſtrictly obſerved upon every ſheep upon which experiments were made. Notwithſtanding ſo long a faſt, the firſt ſtomach contained a large quantity of graſs, ſomewhat triturated; and though it had fed upon this before the experiment, it was not yet digeſted. In the

midſt of this graſs, that was thoroughly imbibed with a greeniſh fluid, with which great part of the ſtomach was filled, lay five of the tubes; the ſixth had paſſed to the ſecond ſtomach, which may be conſidered as an appendix to the firſt. The herbs which I encloſed in the tubes, after impregnating with my ſaliva, were beet, trefoil and lettuce; for three tubes I had uſed them green, and for the reſt dry. Upon opening all the ſix, I could not perceive that either the freſh or the dried plants had ſuffered any diminution, or undergone any degree of real concoction; they had only become a little tenderer, and the freſh herbs had loſt their green colour; in ſhort, the reſult of this experiment was exactly like that of Reaumur's.

CXXXVIII. I ſhould then have ſuppoſed, that in theſe animals digeſtion depends on the triturating power of the ſtomach, if it had not occurred, that, as the herbs encloſed in the tubes had not paſſed further than the firſt ſtomach, they might not perhaps have felt the influence of that kind of gaſtric fluid, which is requiſite for the concoction of the food: for it is very poſſible that this fluid may reſide in ſome of the other ſtomachs, and eſpecially in the fourth, in which the aliments of animals with four ſtomachs, ſuch

 as

as ſheep, are always found in the ſtate of a very ſoft paſte. Reaumur indeed did not perceive any ſign of digeſtion even in the tubes that had been voided at the anus, and conſequently muſt have paſſed through the other ſtomachs. But this obſervation reſted upon a ſingle experiment; and to illuſtrate ſtill further a matter of ſuch importance, it could not but be proper to repeat it. I therefore treated another ſheep in the ſame manner, and allowed it to live thirty-ſeven hours afterwards, that the tubes might have time to paſs beyond the firſt ſtomachs. They did in fact paſs beyond them; and I found all ſix in the fourth, which anſwered the end I had in view; the three ſpecies of plants however, mentioned above (CXXXVII), both the green and the dry, were entire, and ſeemed only a little ſoftened by maceration.

CXXXIX. I was now about to declare in favour of the neceſſity of trituration in this animal, when a doubt occurred. Neither Reaumur nor myſelf had adverted to a circumſtance, which ever precedes digeſtion, both in ſheep, and every other quadruped endowed with four ſtomachs, as goats, oxen, deer, &c. I mean rumination. We are taught, both by diſſection and daily experience, that the food, when it has arrived at the ſecond ſtomach,

does

does not immediately proceed to the third, and thence to the fourth, but, on the contrary, returns, and re-aſcends up the œſophagus; and when it has reached the cavity of the mouth, is maſticated and ground over again, and impregnated with a large quantity of ſaliva; this proceſs is repeated, till it becomes fit to be digeſted. I therefore entertained many doubts whether the phænomena obſerved by Reaumur and myſelf, were not rather owing to the want of rumination than of trituration. Wherefore, in order to decide with certainty concerning digeſtion in ſheep, I perceived it would be neceſſary to repeat the experiments with plants previouſly triturated. And I did not conceive that this trituration was any thing ſo peculiar in ruminating animals, that it could not be ſupplied by man, provided he maſticated the herbs well, and impregnated them thoroughly with ſaliva. I therefore performed this eaſy operation; the uſual tubes were employed; in three of them pieces of the green plants were encloſed, and in three others of the dried; but both had been well maſticated: the lines and nerves that traverſe the leaves, were however eaſily diſtinguiſhable. Leſt, when thus broken down and divided, they ſhould paſs out at the lateral pores, or through the meſhes

 of

of the lattice-work, I thought it would be proper to enclose each tube in a linen bag; supposing that in the present case that it would not be broken, since that muscular action, which is so considerable in gallinaceous fowls, does not exist in the animals in question. I gave the six tubes to a ram, together with six others, filled with the same plants, but not previously masticated, that I might be able to form a comparison. Fourteen hours after the animal had taken them, he vomited three at once; and in thirty-three hours five more were voided at the anus; at the end of two days he was killed. Of the four remaining tubes, two were found in the stomach, and the other two at the end of the duodenum; the bag in which they were enclosed was entire. The tubes that had been vomited had received more or less injury; the contents of two had not been masticated, nor had they undergone the smallest alteration. The contents of the third had been masticated, and were evidently wasted; for they now occupied little more than half the tube, whereas at first they had entirely filled it; they had acquired a subacid taste. Many of the pieces having lost their natural firmness, broke when I attempted to stretch them; the nerves only made some resistance.

In

In two of the tubes voided at the anus, the pieces of plant had not been masticated; these did not seem at all diminished, nor was the cohesion of the parts destroyed; on the contrary, the plants in the other three (which had been masticated) were reduced almost to nothing; the small remains consisted of bare nerves, with a little of the leaf attached; and both the one and the other were so much softened, that the slightest force was sufficient to break them. The bag in which they were enclosed was dyed green, particularly in its inside; when twisted and pressed between the fingers, it yielded a livid yellow juice, of an acid taste. This was far from being the case in the bags which contained the two tubes, of which the contents had not been chewed; their inside had scarce a shade of green; and this shade was still less perceptible in the juice expressed from them. With respect to the tubes found in the last stomach, and at the end of the duodenum, the contents of the former had acquired a deep green colour, were a little macerated, but had not lost much of their natural firmness, and did not appear to be diminished in bulk. They had not been masticated, but those of the two others had; and of them there remained only some of the largest nerves, which were themselves very

tender, and half decompoſed. I have already obſerved, that the tubes voided at the mouth were more or leſs bruiſed; but all the reſt were quite free from injury.

CXL. The reader is already aware of the immediate conſequences of theſe experiments. In the firſt place it appears, that the gaſtric fluid of ſheep has no effect in digeſting plants, unleſs they have been previouſly maſticated; otherwiſe it can only produce a ſlight maceration, nearly as common water would do in a degree of heat ſomewhat exceeding the medium temperature of the atmoſphere. Secondly, this fluid is abundantly capable of digeſting plants, provided they are previouſly reduced to pieces by maſtication; its firſt effect is to ſoften them, and deſtroy their natural conſiſtency; it then proceeds to diſſolve them, not even ſparing the tougheſt parts, ſuch as the nerves of the leaves; of this ſolution we have a clear proof in the green colour that appears on the linen encloſing the tubes, and in the juice expreſſed from it (*a*). Thirdly, the triturating power of the ſtomach does not at

(*a*) During my agreeable reſidence at Geneva in the ſummer of 1779, I had what I had long wiſhed for, the ſatisfaction of being perſonally acquainted with my illuſtrious friend Mr. Bonnet, and of enjoying much of his converſation. I had alſo an oppor-

at all contribute to digeſtion in ſheep, but this proceſs is entirely effected by the gaſtric juices. Fourthly, no ſuch power exiſts in ſheep, as we ſee from the tubes that were voided at the anus and found in the ſtomach having ſuſtained no injury, notwithſtanding preſſure alone between

opportunity of taking his opinion on ſome productions, which I deſigned to publiſh, and particularly the preſent work concerning digeſtion. Three other reputable philoſophers and excellent judges of the ſubject were preſent at the reading, Mr. Abraham Trembley, Mr. Johannes his worthy nephew, and Mr. Senebier, Librarian of the Republic of Geneva; and it did not appear to me, that my labours were diſapproved by this reſpectable aſſembly. Mr. Bonnet gave me a book to peruſe on the ſame ſubject, which, as it was new to me, made us apprehenſive, leſt the author ſhould have anticipated me; it was intituled, "Eſſai ſur la Digeſtion, & ſur les principales Cauſes de la Vigueur & de la Durée de la Vie. Par Mr. Batigne, M.D. Berlin, 1768, 12mo." But I was ſoon aware, that Mr. Batigne and myſelf had purſued very different paths; in his book he does not enter into any experimental enquiry concerning digeſtion, but confines himſelf to reflections, which, although they are very pertinent and ſenſible, are calculated rather to excite than ſatisfy the reader's curioſity. Hence I ſhould not have mentioned it, but for ſome objections ſtarted againſt Reaumur's Memoirs on Digeſtion. Theſe I ſhall touch upon in a few ſhort notes, at ſuch places of the text as they ſeem moſt connected with. And here it is proper to mention one objection relative to the digeſtion of ruminating animals, which, before I was acquainted with Mr. Batigne's book, I had myſelf urged againſt Reaumur, and which experiment proves to be perfectly juſt. It conſiſts in ſhewing, that the French naturaliſt had omitted the maſtication of the plants encloſed in the tubes before he introduced them into the ſtomachs of ſheep, which was the reaſon why they were not digeſted.

tween the fingers is ſufficient to flatten them. The contuſion of the tubes that were vomited is no proof of the contrary, ſince it is evident, that this contuſion was produced by the teeth of the animal during rumination. Laſtly, theſe vegetables acquire a ſlight acidity during ſolution, but of this we ſhall have another opportunity of ſpeaking hereafter (*a*).

CXLI. This quadruped feeds not only upon graſs, but upon corn alſo whenever it meets with it; it is likewiſe very fond of bread. In order therefore to confirm ſtill farther what has been advanced, I thought it would be proper to make an experiment upon ſome kind of grain. I ſelected wheat for this purpoſe; and as wheat may be procured under the various forms of ſeed, flour, and bread, I choſe to make trial of all three. Six tubes were filled, three with thoſe ſubſtances without any other preparation, and three others with the ſame after they had been well maſ-

Nearly the ſame objection is urged by the learned phyſician in theſe terms; "The experiments (of Mr. de Reaumur) upon ruminating animals are ſtill leſs concluſive; the graſs contained in the tubes could be only macerated, ſince it was neither chewed nor broken down a ſecond time by rumination." (L. c. Troiſieme Reflexion ſur les Experiences de Mr. de Reaumur). It was a piece of juſtice due to Mr. Batigne not to overlook this paſſage.

(*a*) In the laſt diſſertation.

ticated,

ticated. The tubes were enclosed in linen bags as before, and given to a lamb six months old. It was killed thirty hours afterwards; none of the tubes were either vomited or voided at the anus; they were found partly in the third and partly in the fourth stomachs. The result of this experiment coincided with that related above (CXL). The grain, flour, and bread, that had not been masticated, were indeed penetrated thoroughly by the gastric fluid, but not at all dissolved. On the contrary, the corn which I had first bruised with a pestle and then ground between my teeth and reduced to a coarse paste, was in great measure consumed; nothing remained in the tubes but fragments of the bran, with some small remains of farinaceous matter adhering. The like had happened to the flour and bread, what remained consisted of a mucilaginous mass, without any appearance of what it had originally been. This matter had a slight degree of acidity, a quality which was far more evident in the bread, flour, and grain that were not dissolved by the gastric fluid for want of previous maceration.

CXLII. The vast quantity of gastric fluid with which ruminating animals are continually supplied, was already known to physiologists, and particularly to the great Haller. After

After a faſt of two whole days, I have found thirty-ſeven ounces in the two firſt ſtomachs of a ſheep. It was green, but I know not whether this colour is natural to it, as the yellow hue is to that of crows (LXXXI); or rather whether it is adventitious, and derives its origin from the plants on which theſe animals feed, of which, notwithſtanding ſo long a faſt, there were ſtill ſome remains in the two ſtomachs. The great quantity of juice I had collected induced me to try whether, like that of ſeveral other animals, it was capable of digeſting food out of the body. I therefore encloſed ſeveral pieces of leaves of lettuce in two ſhort glaſs tubes (which I had previouſly filled with the juice), and ſealed them with wax at each end. The contents of one tube, as before, were maſticated, while thoſe of the other were left untouched. It was proper on the preſent occaſion to employ a term of compariſon, by repeating the ſame experiment upon two other tubes filled with water. That theſe four tubes might be expoſed to a degree of heat nearly equal to the temperature of ſheep, I fixed them under my axillæ, two under each axillæ, where they continued forty-five hours. The leaves immerſed in the gaſtric fluid, which had been previouſly macerated, had undergone

gone no inconſiderable change. Beſides the loſs of their bright green colour, they were converted into a kind of glue, in which it was juſt poſſible to find, with the point of a penknife, a few nerves, which were the only remains of the organization of the plant. This was far from being the caſe with the leaves that had not been maſticated; for all the pieces were diſtinguiſhable, and the only difference was, that they did not make ſo much reſiſtance as at firſt. The leaves immerſed in water, both thoſe which had been chewed, and thoſe which had not, had not loſt either their colour or conſiſtence. From this compariſon it appears, that the gaſtric fluid does not act on the plant as a mere aqueous fluid, but as a real ſolvent, nearly as it acts in the ſtomach itſelf. Nor was the heat to which it was expoſed under my axillæ a condition without its part in the production of this incipient digeſtion; for in pieces of the ſame leaves of lettuce maſticated in the ſame manner, but kept in my apartment, of which the temperature was about ſixteen (*a*) deg. there appeared only a ſuperficial maceration, notwithſtanding they remained immerſed in the ſame gaſtric fluid for the ſame ſpace of time.

(*a*) Sixty-ſix, Fahren.

CXLIII. I closed my enquiries concerning the digestion of ruminating animals by some experiments on oxen. In these the same tubes and plants were employed as before, and the results perfectly coincided with those obtained from sheep; only in the present instance, Nature was more speedy in her operation. In less than twenty-four hours the tubes, which had been given to two oxen, were voided along with the excrements not in the least contused or injured. When taken out of the linen bags and examined, they were found to contain little more than the bare ribs and nerves of the leaves of beet, lettuce, and trefoil (which leaves had been previously masticated). The nerves were also in some degree macerated, and the slightest force was sufficient to break them. On the contrary, pieces of the same plants that had not been subjected to maceration were indeed slightly concocted, and their colour was a little faded, but they were entire. When applied to the tongue, they tasted subacid, like those which had been in the stomachs of sheep (CXXXIX, CXLI).

The horse does not chew the cud, but he resembles the ox in the membranous structure of his stomach, and the food upon which he lives. I was therefore desirous of seeing what changes masticated plants would under-

go

go by continuing a certain time in the ſtomach of this quadruped alſo, encloſed as uſual in tubes. Here too they were digeſted, as I learned from ſome lettuce and trefoil encloſed in two tubes, which were voided in fifty-two hours.

CXLIV. When I reflect upon the various animals to which my enquiries concerning digeſtion have been hitherto extended, I perceive, that the ruminating ſpecies very nearly reſemble birds endowed with muſcular ſtomachs, with reſpect to the action of the gaſtric fluid. In both, that fluid requires an agent capable of breaking down and triturating the food, before it can diſſolve and digeſt it. From the mouth of granivorous birds, where it undergoes no real alteration, the aliment paſſes immediately into the craw, where it is ſoftened and macerated; from this receptacle it deſcends into the ſtomach: the triturating power of this organ performs the office of teeth, and breaks, grinds, and, if I may ſo ſpeak, pulverizes it, and thus renders it fit to be diſſolved by the gaſtric fluid, and converted into chyme. Nature employs a ſimilar contrivance in ruminating animals. The hay and graſs deſcend immediately into the firſt and ſecond ſtomachs, in nearly the ſame ſtate as when they were browſed. Here they are ſoftened by the great

quantity

quantity of gaſtric juices, as ſeeds in the craw of birds with gizzards. But as the ſtomachs of ruminating quadrupeds have no ſenſible triturating power (CXXXIX, CXL, CXLIII), and the food requires trituration, nature has wiſely provided for this by cauſing it to aſcend, in conſequence of a gentle ſtimulus to vomit, into the cavity of the mouth, where, by means of rumination, it receives the neceſſary predispoſition to be digeſted by the gaſtric fluid, as happens to the food in the ſtomachs of granivorous fowls, after they have been properly triturated by the gaſtric muſcles.

DIS-

DISSERTATION IV.

THE SUBJECT OF DIGESTION IN ANIMALS WITH MEMBRANOUS STOMACHS CONTINUED. THE LITTLE OWL. THE SCREECH OWL. THE FALCON. THE EAGLE.

CXLV. REAUMUR having treated in his firſt memoir of the mode of digeſtion in granivorous and herbivorous fowls which are provided with gizzards, proceeds in his ſecond to enquire into the nature of that function in carnivorous birds, of which the ſtomach is membranous. From the facts related in the firſt memoir he concludes, that there does not exiſt in the gizzard any ſolvent capable of ſeparating the particles of the food. This ſeparation, he thinks, is effected by a force reſembling that exerted by mill-ſtones, viz.

viz. the action of ſtomachs of this conſtruction upon their contents. He is moreover of opinion, that the facts adduced in the ſecond memoir prove the exiſtence of a menſtruum in membranous ſtomachs, capable of diſſolving and digeſting the aliment without borrowing any aid from the action of the ſolid parts.

As the great object of the firſt diſſertation was to enquire by experiment into the mode of digeſtion in fowls with muſcular ſtomachs, I had there an opportunity of conſidering fully Reaumur's experiments on that ſubject; and we have accordingly ſeen, that the conſequences he has deduced from them are by no means to be admitted in their full extent. This is plain from the XXXIX, XL, XLI, XLII, XLIII, XLVth paragraphs, to which, for the ſake of avoiding uſeleſs repetitions, I refer the reader. The preſent diſſertation, in which the ſubject of digeſtion in membranous ſtomachs is continued, is the proper place for conſidering the experiments related in the ſecond memoir. As of all fowls birds of prey approach neareſt to man in the ſtructure of the ſtomach, he choſe one of thoſe large kites that are common in France, for the ſubject of his enquiries. The periodical vomiting, common to all birds of prey, allowed the French naturaliſt to make a variety of experiments on the

the ſame individual. He employed tin tubes filled with different ſubſtances, eſpecially fleſh, which, after having been ſome time in the ſtomach, were thrown up, and gave him an opportunity of examining the effects produced upon the contents. That the fleſh was more or leſs digeſted according to the length of its continuance in the body of the animal, was the general and invariable reſult obſerved by Reaumur (*a*). Hence he juſtly infers, that in this caſe digeſtion is produced by the gaſtric fluid, without the concurrence of any triturating power. He mentions ſome

(*a*) Mr. Batigne thinks, that fleſh encloſed in tubes was inſufficient to convey a preciſe idea of the alteration it undergoes in the ſtomach, as it is only macerated in tubes, and not digeſted. " On voit de plus que la viande miſe dans les tubes ne peut donner une idée preciſe des changements qu'elle ſubit dans l'eſtomac de l'animal, puis qu'elle n'y eſt que macerée & non point digerée." (*L. c. premiere Reflection ſur les experiences de M. de Reaumur.*) The author muſt allow me to obſerve, that in this attack he miſrepreſents Reaumur, who, p. 465, &c. of the Mem. of the Roy. Acad. expreſsly ſays, that the fleſh given to the kite was not merely macerated or ſoftened, but completely digeſted, and at laſt entirely conſumed. He might indeed have objected to the ſmall number of his experiments, as inſufficient to aſcertain the efficient cauſe of digeſtion, if that philoſopher, whoſe ingenuouſneſs was equal to his ſkill, had not perceived and publicly owned it himſelf. That tubes, provided the experiments are properly made and varied, are well adapted to ſhew the change produced upon food in the ſtomach, will be abundantly proved by the facts adduced in this treatiſe.

 other

other experiments, which I ſhall have occaſion to conſider below, and concludes from analogy, that digeſtion in other birds with membranous ſtomachs is produced in the ſame manner. He laments, however, that from the death of his kite, and his neglecting to ſubſtitute other animals in its ſtead, he could not adduce facts ſufficiently numerous to illuſtrate the ſubject fully. He promiſes to ſupply the deficiency on ſome future occaſion, but his death, by which a few years afterwards natural philoſophy loſt one of its great ornaments, prevented him from fulfilling his promiſes.

CXLVI. I do not preſume that I ſhall be able to accompliſh, what neither this illuſtrious naturaliſt, nor any other, as far as I know, has effected. But ſimply with the view of continuing my obſervations and reflections on digeſtion in fowls with membranous ſtomachs, I ſhall relate ſome experiments on different birds of prey, of which ſome ſeek it by night, and others by day. Among the former, I have uſed ſuch as I could moſt eaſily procure, the little owl and the ſcreech-owl. The food which I gave the firſt-mentioned ſpecies (*a*),

(*a*) This ſpecies is called by Buffon *petite chouette*, Hiſt. Nat. des Oiſeaux, T. 2. Ed. in 8vo. and by Linnæus *ſtrix paſſerina*, l. c.

and

and which it eagerly devoured, has enabled me to ſolve, among other problems, one that exerciſed the ſagacity of M. de Reaumur. Finding that the gaſtric fluid of the kite digeſted fleſh, he wiſhed to know whether it would alſo digeſt vegetables; a circumſtance he did not think probable, when he conſidered the repugnance carnivorous birds ſhew for them; and ſo in fact it happened. When beans, peaſe, wheat, incloſed in tubes, had lain ſome time in the ſtomach, they were thrown up juſt in the ſame ſtate as they had been ſwallowed: nor did boiling diſpoſe them to be diſſolved any better by the gaſtric fluid. Some ſparrows, which I gave my owls, afforded me an opportunity of obſerving the ſame phænomenon. As they ſwallowed them whole, they of courſe would receive into the ſtomach feathers and food not yet digeſted by the ſparrows, and conſiſting of grain or bread. Now, after the fleſh has been digeſted, the feathers are vomited generally in the form of a hard ball; and along with the feathers the grain, which, though it is much ſoftened by maceration, yet continues whole. And if the matted feathers be diſentangled, we may generally perceive evident traces of bread. Hence we have a clear proof that the gaſtric fluid produces no change on ſuch vegetables.

CXLVII. This fact, simple as it is, shews two things, of some importance: first, that the stomach of this bird is really membranous, and without any power of trituration: this appears from the grains (CXLVI) continuing whole, though they had been soaked till they were become so tender, as to burst on being gently squeezed between the fingers. I would not however affirm that the stomach has no action at all; for the globular mats of feathers can only be produced by this viscus contracting as the flesh is digested.

The digestion of the bones also deserves attention. It cannot be said that they are voided along with the excrements; for I must soon have been aware of this, as I kept my owls in cages; nor, for the same reason, could it have escaped my notice if they had been vomited. I have indeed sometimes found two or three little bones, as a dorsal vertebra, or a piece of the cranium, among the matted feathers, but never any thing like the whole skeleton. We must therefore conclude that they are digested.

CXLVIII. Reaumur's kite was capable of digesting bone, though of the hardest texture, and enclosed in tubes (*a*). Though the experiment just related is sufficiently de-

(*a*) Mem. cit.

cisive,

cisive, yet, as the bones were loose in the stomach, in order to be absolutely certain that the effect was produced by the gastric fluid alone, it was proper to repeat it with a tube; with this view a piece of the thigh of a pigeon was put into one of the same tubes that I used before: thus two experiments, one on the digestion of flesh, and another on that of bone, were made at once. By long practice upon birds of prey, I learned how to keep the tubes in the stomach as long as I pleased. When I had given one of my tubes to an owl, after it had been full fed, I found it was not thrown up till all the food was digested. This observation is applicable to all other birds of prey. The same thing also happened when they were fed sparingly. All the difference was, that as the full stomach requires more time to be emptied, the tubes were retained longer, and *vice versa*, when they were fasting, the tubes were sure to be returned in two or three hours. This observation, together with the knowledge I had acquired from experience, of the time these birds take to digest a given quantity of food, enabled me to guess pretty exactly how long the tubes would continue in the stomach.

I return now to the tube in which part of a pigeon's thigh had been put. After seven-

teen hours continuance in the ſtomach, the bone was no where changed except at the broken ends, which were a little ſoftened. The fleſh, by which it was covered, as well as the integuments, had begun to be diſſolved, for the ſurface was become exceedingly tender. In fourteen hours more greater effects were produced. The fleſh was conſiderably waſted; the bone was ſhortened at the ends, and was ſo ſoft, as to yield to the preſſure of the finger. In twenty-ſeven hours more, there was no remains of fleſh or perioſteum, and the bone was a good deal ſhorter than at firſt. I could not but be deſirous of ſeeing the end of the experiment, and therefore replaced the bare bone in the tube. When it had remained twenty-one hours in the ſtomach, it had loſt the marrow, and the internal cavity was enlarged, though the girt was leſſened. This aroſe from the corroſion of the internal and external ſurfaces at the ſame time. Both ſurfaces were covered with a yellow fluid, that had at once a bitter and ſalt taſte; and points of gelatinous matter were diſperſed over them. The bone, thus half diſſolved, was put again into the tube, and left thirty-two hours longer in the ſtomach. If the reader will conceive a cylinder of thin paper, uneven at the ends, and per-

forated

forated with ſeveral holes, he will have an idea of the ſtate of the bone when it was taken out of the tube. It was covered with the ſame fluid, which muſt have been the gaſtric liquor; and the gelatinous points now alſo were diſperſed over the ſurface of the leaf; this jelly was the oſſeous matter itſelf, reduced to this ſtate by the action of the gaſtric fluid. Laſtly, nine hours longer continuance in the ſtomach, left only a few ſmall chips. This one experiment convinced me, that the gaſtric fluid of the little owl is capable of digeſting bone as well as fleſh, without the concurrence of any external agent: it alſo ſhews the gradual progreſs of digeſtion.

CXLIX. Having ſo far ſatisfied my curioſity, it remained to enquire into the nature of this fluid, and its effects out of the animal body. With the ſmall ſpunges, by means of which I obtained ſo large a quantity from crows (LXXXI, LXXXII), I procured it in due proportion from the ſpecies of owl in queſtion. I ſay in *due proportion*; for it is evident, that as the ſtomach of theſe birds will not admit ſo many tubes as that of crows, it cannot yield ſo much gaſtric fluid. Beſides, I had only ſix little owls, whereas I could get as many crows as I pleaſed. It was wonderful how ſoon the ſpunges were

filled with liquor. As they were introduced into the empty ſtomach, they were ſoon thrown up, agreeably to an obſervation made above (CXLVII); and yet they were as full of juice, as if they had been dipped in water; and freſh ones immediately forced down the throat, yielded a nearly equal quantity. I obſerved the ſame thing in crows (LXXXIII). Whence it appears, with what care Nature provides a large ſupply of gaſtric liquor in theſe animals, as digeſtion is entirely dependent upon it. The juice was inſtantly ſqueezed out of the ſpunges into a ſmall glaſs; it appeared to have the fluidity of water, but was of a reddiſh-yellow colour, like the yolk of an egg. This colour was not inherent in the gaſtric liquor itſelf; it aroſe from an immenſe number of very ſmall yellow corpuſcles, ſcarce perceptible by the naked eye, but eaſily ſeen by help of the microſcope. In a few hours they ſubſided to the bottom, in the form of a yellow ſediment, and left the fluid above tranſparent, like water, where it has been freed from mud that was diffuſed through it and rendered it turbid. The firſt time I ſaw this phænomenon, I ſuſpected it was owing to ſome impurities that remained in the ſtomach, and were mixed with the juice. Before the next experiment, in order

to

to be certain that the ſtomach was free from heterogeneous ſubſtances, I kept the animal faſting for a longer time than uſual; but this did not prevent the yellow colour from appearing. Upon opening the ſtomach of an owl that had been long kept faſting, I could find no foreign ſubſtance, but the fluid was as yellow as that ſqueezed out of the ſpunges. I was therefore convinced that theſe particles, though I could not diſcover their origin, did not come from any remains of the food. The gaſtric liquor of the little crow, like other gaſtric liquors, is a little ſalt and bitter: it evaporated ſooner than water. It leaves a ſediment of the yellow particles, which gradually becomes dry, and forms a blueiſh yellow cruſt; it is not at all inflammable. It has one property common to every gaſtric fluid I have hitherto examined, or ſhall have occaſion to mention in the ſequel; though it is expoſed to the open air for weeks and months, in the hotteſt ſeaſon, it never becomes putrid.

CL. Such are the properties of the gaſtric liquor of the ſmall owl, when examined alone. Let us proceed to the effects it produces on fleſh out of the body. In theſe experiments I uſed calves inteſtines, a kind of food which this bird devours very greedily.

dily. Forty-ſix grains were immerſed in ſome recent gaſtric fluid; and at the ſame time an equal quantity of the ſame inteſtine was put into a phial exactly like the former, and an equal quantity of water was poured upon it. Whenever I have made experiments, with a view to compare the effects of the gaſtric liquor and water, I have taken care that all circumſtances ſhould be alike. To prevent evaporation, the mouths of the phials were ſtopped with paper; they were ſet near a kitchen fire, where the uſual heat was between thirty and thirty-five degrees. In eleven hours ſome black ſpots began to appear upon the inteſtine in the gaſtric fluid, which were at firſt thinly ſcattered over it, but became gradually more numerous, till in twenty-four hours they almoſt covered it. During the formation of the ſpots, I examined the inteſtines with the microſcope, and found that where they appeared, the fleſh was ſoftened, and had loſt its fibrous texture. When they had ſpread over the whole piece, I took it out of the liquor, and waſhed it with pure water; and now it recovered its white colour, for the black covering conſiſted of a thin ſtratum of fleſh, which the gaſtric fluid had concocted. It was very eaſily rubbed off, and fell to the bottom of the water in ex-

ceedingly

ceedingly ſmall particles, where it formed a black ſediment, and when viewed by the microſcope, ſeemed to be a collection of molecules of fleſh, with no appearance of fibres. When the piece of gut was dried, it weighed only twenty-eight grains, and had therefore loſt eighteen; the piece that had ſtood in water for the ſame length of time, was quite fœtid; whereas the other emitted no diſagreeable ſmell: after waſhing and drying, it was found to have loſt ſeven grains. Both pieces were again put into the phials, with the ſame quantity of water and gaſtric fluid, and left in their former ſituation for two days. The latter had now loſt its ſhape and organization, and was converted into a black mucilage, of which the particles had no longer any coheſion. The gaſtric liquor had therefore diſſolved the piece of inteſtine completely; an effect, which neither water nor putrefaction had produced upon the other; for there was a remainder of nineteen grains, that not only retained its fibrous ſtructure, but made conſiderable reſiſtance when I attempted to tear it.

CLI. I did not neglect to examine the ſtomach and œſophagus of this ſpecies of owl, as I conceived that it would be improper to omit a brief deſcription of theſe organs

gans in the animals upon which my experiments were made. If the beginning of the duodenum be tied, ſo as to ſtop the air from paſſing, and the upper end of the œſophagus be inflated, we get a view of the œſophagus and ſtomach dilated to their utmoſt extent; together they reſemble a pear, or rather a gourd, of which the belly is formed by the ſtomach, and the neck by the œſophagus; when viewed againſt the light, the latter appears ſemi-tranſparent, and the former quite opake. If they are cut longitudinally, and ſpread upon a table, we find that the tranſparency of the œſophagus is owing to the thinneſs of its ſides, which thicken as they deſcend, and render the lower part as opake as the ſtomach. It becomes not gradually, but ſuddenly thicker, from the multitude of follicular glands that form the ſame kind of tranſverſe faſcia, that I have deſcribed in other birds; in this ſpecies it is about five lines broad. Theſe glands continually ſecrete into the cavity of the œſophagus a liquor almoſt inſipid, of a turbid white colour, and of ſome denſity; in a word, reſembling the œſophageal juice of other birds. At the beginning of the ſtomach the follicles diſappear, nor could I find the ſmalleſt veſtige of any thing like them in the coats, though I

ſearched

ſearched with care. Are we then to ſuppoſe that the fluid, which is always to be found in the ſtomach, derives its origin from the numberleſs glands lying at the bottom of the œſophagus? this is probably true of ſome part of it; but that no ſmall part comes alſo from the arteries of the ſtomach itſelf, the moiſture, like what I have deſcribed in other animals (XCIII, CXXXII), has furniſhed me with an indubitable proof; for it immediately appears again, though it has been wiped off ever ſo clean.

CLII. This deſcription will apply to the œſophagus and ſtomach of ſcreech-owls: I have made experiments on two ſpecies of owl; one variegated with many colours, among which the red and brown, or dull yellow, predominate; upon the head are two curious tufts, in the ſhape of a creſcent; the other ſpecies has not this tuft, but is adorned with a greater variety of elegant colours; the iris is duſky, in the former it is yellow (*a*). My firſt experiment was made upon one of the long-eared owls, and the reſult greatly ſurprized me. It threw up two tubes in about three hours after it had taken them, nor was

(*a*) The former ſpecies is called by Linnæus *ſtrix otus*, and *moyen duc* by Buffon; the latter *ſtrix ſtudula* and *chat huant*.

the

the flesh at all changed; I could not perceive any alteration, even when it had continued upwards of seven hours in the stomach. If I had not been very cautious in forming opinions, I should have concluded, that the gastric juices of this species are insufficient of themselves to produce digestion; but I reflected, that a single experiment did not warrant such a conclusion, and that some adventitious circumstance might have affected the result. The bird seemed quite stupid, and reduced very much in its flesh; hence it was probably unhealthy, and consequently incapable of digesting its food properly. This suspicion was confirmed by the account of the person from whom I had it, who informed me, that it had refused food ever since it was taken, which was now four days. It was an old bird; and, upon turning to Buffon, I found that, in order to rear individuals of this species, it is necessary to catch them young, for the old ones will not take sustenance in confinement (*a*). In two days and a half longer, that in my possession died without taking any food of itself; it had always returned what I forced down the throat.

CLIII. This owl fell into my hands in winter; the spring following I procured two

(*a*) A. l. c.

young

young ones from the neſt, which devoured food with eagerneſs whenever they were hungry: I now repeated my experiment, and the reſult was exactly the reverſe of the preceding; the fleſh in the tubes ſhewed ſigns of ſolution in three hours and three quarters, and in ſeven was entirely diſſolved. This convinced me, that the failure of the foregoing experiment was not owing to the inefficacy of the gaſtric fluid, but to the morbid condition of the animal; which either leſſened its quantity, or, what is more probable, impaired its quality. I might, therefore, have omitted mentioning that failure; but it was better to relate it, in order to ſhew, that when the food incloſed in tubes is not digeſted, we are not immediately to infer, that the gaſtric fluid is not capable of producing this effect.

CLIV. But my young owls digeſted not only fleſh, but bone; and that of a hard texture, ſuch as the bones of ſheep and oxen, not to mention thoſe of pigeons and fowls. The reſult was eſſentially the ſame as in the preceding ſpecies (CXLVII, CXLVIII); inſtead, therefore, of dwelling upon it, I will relate, at ſome length, a fact, which, in my opinion, deſerves to be noticed. I gave one of my owls a frog, and an hour afterwards killed it. The ſtomach though exceedingly dilated,

dilated, was incapable of containing the whole frog, of which the head lay in the œſophagus, and ſtretched its ſides conſiderably; the hind legs lay at the bottom of the ſtomach, and the fleſh was ſo much waſted, that the bones were nearly bare: the integuments of the thighs and trunk were almoſt corroded, and the fleſh was as tender as if it had been boiled. The head, which lay contiguous to the faſcia of follicular glands at the bottom of the œſophagus, had begun to be diſſolved. This experiment ſhews not only that fleſh is digeſted with great quickneſs by the gaſtric liquor, but likewiſe that it is digeſted equally ſoon in the œſophagus and ſtomach; an obſervation I had not yet made upon any other animal.

CLV. Before I killed both theſe owls, I was deſirous of having ſome of their gaſtric juice, that I might ſee whether it retained like others its power of digeſtion; and I found, that it completely diſſolves fleſh, when it is aſſiſted by a proper degree of heat.

CLVI. In the other ſpecies, the *tawny owl*, the ſame phænomena occurred with reſpect to the ſolution of fleſh and bone in the tubes, whether we conſider the digeſtion of fleſh and bone in tubes, or the ſpeedy digeſtion in the

the œſophagus (*a*), or the remarkable ſlowneſs of that proceſs out of the body. Upon an individual of this ſpecies I made an experiment, which had been unſucceſsful on the *little* owl. Obſerving, that when they were hungry and open their beak very wide, if I dropped a pea, French-bean, or cherry into it they ſwallowed it with as much avidity as if it had been the pleaſanteſt kind of food, I was deſirous of ſeeing whether the ſtomach would digeſt vegetable ſubſtances. With this view I encloſed ſome of the ſeeds juſt enumerated in tubes, and forced them down the throat, but to no purpoſe; for though the liquor ſwelled them, and perhaps altered the colour, they underwent no diminution of bulk. They were thrown up undigeſted in a day or two, a circumſtance which ſufficiently ſhews, that ſuch kind of food, notwithſtand-

(*a*) When I was writing this paſſage I was ſtruck by a reflection; for which this is the proper place. If we compare the preſent with the LXXVII, LXXVIII, LXXIX, XCIX, C, CI, CXXXV, CLIVth, it will appear, that the œſophageal before its mixture with the gaſtric fluid, in many animals, is endowed with ſome degree of digeſtive power. Though it generally exerts this power only when mixed with the gaſtric fluid, yet in ſome animals, which ſwallow their food with great eagerneſs and have not room enough in the ſtomach to contain it all, in conſequence of which part muſt be lodged in the œſophagus, digeſtion takes place there.

ing the birds appear to relish it, is ill adapted to their gastric juices. The greediness with which they swallow such substances can arise only from that blind appetite, in consequence of which young birds take whatever is offered them.

CLVII. Being satisfied with these experiments on nocturnal birds of prey, I turned my attention to some of the diurnal ones. My first subject was a falcon given me by my illustrious friend the abbe Corti, formerly professor of natural history at Reggio, and now superior of the College of Nobles at Modena, a philosopher well known in the republic of letters by several fine publications. It was of the size of a common hen, and appeared to belong to the species denominated *lanarius* by Linnæus. I soon found, that I could not handle this bird so familiarly as those which I have had occasion to mention hitherto. Its strong beak and long sharp talons would not easily permit me to open the mouth by force, and thrust the tubes down the throat. I however contrived a method of introducing them into the stomach unperceived by the bird; it consisted in cutting some flesh in pieces, making holes in them, and concealing the tubes in these holes. When the falcon was hungry he ran eagerly to the pieces of flesh

fleſh, and ſwallowed them whole. For the fraud to ſucceed, it was neceſſary that the tubes ſhould be quite covered with fleſh; for if any part of them was bare, the falcon would put them under his talons and tear the fleſh away with his beak and ſwallow it without the tubes.

CLVIII. My firſt experiment was made with a view to aſcertain, whether it was capable of digeſting bone independently of the action of the ſtomach, which proved to be the caſe; but I have before ſaid ſo much on the ſubject of the digeſtion of bone, that I ſhould forbear to relate the preſent inſtance particularly but for a new and important phænomenon, which renders the detail neceſſary. The bone conſiſted of little ſplinters of an ox's thigh bone; they were very hard and compact, and of various ſizes, from that of a grain of wheat to that of a bean; they weighed together ſixty-ſeven grains; I put them into two tubes, in which they were rather cloſely crammed. To prevent their falling out of the tubes when they began to be diſſolved, and conſequently to get looſe from each other, I put the tubes in a linen bag, a precaution which I had before employed, and continued to employ occaſionally in future. In twenty-four hours the bones had ſhifted their re-

ſpective places and rattled in the tubes, a circumſtance that ſhewed the bulk to be diminiſhed. They were moiſt with gaſtric liquor, but had none of thoſe gelatinous points which I had ſeen in an experiment both on the *little* owl (CXLVIII), and the two other ſpecies. Theſe points were, as I then remarked, the oſſeous matter converted into jelly or chyme by the gaſtric liquor. But what is extraordinary was, that theſe ſplinters retained their original hardneſs and rigidity; ſo that at firſt ſight one would not have ſuppoſed, that the fluid of the ſtomach had had any effect upon them. However, the contrary was certain; for when the gaſtric liquor was wiped off, they weighed only forty-two grains. I now replaced them in the tubes, and examined them again after they had been two days in the ſtomach. The pieces of the ſize of grains of wheat were all deſtroyed but two, which were now no larger than millet. Three of the ſplinters were at firſt as big as beans, but now reduced to the ſize of maize. Thoſe of an intermediate ſize were diminiſhed in proportion. During the whole time they all continued hard. At the third examination, after fifty-ſeven hours longer continuance in the ſtomach, the three large pieces only were left, and they were now

now not larger than millet; when I ſtruck them with an hammer, I found that they retained their original hardneſs.

The gaſtric liquor therefore of the falcon does not, like that of owls and many other animals, inſinuate itſelf into the ſubſtance of the bone, but acts on the ſurface only. The phænomenon, I think, may be thus explained: conceive a bone to be compoſed, like wood, or to bring a more familiar inſtance, like an onion, of a great number of ſtrata. The ſtrata of the onion are of conſiderable thickneſs, but we muſt imagine, that in bone they are exceedingly thin. The gaſtric fluid of owls or other animals will firſt diſſolve the upper ſtratum, but while it is doing this it will penetrate and ſoften the contiguous ſtrata, without diſſolving them. Hence the tenderneſs of bone that has lain in the ſtomachs of animals. On the contrary, we muſt ſuppoſe, that the gaſtric liquor of the falcon has no power of penetrating the internal ſtrata, but that its action is limited to the ſurface. According to this ſuppoſition the bone will be digeſted without having the internal parts ſoftened, and thus ſtratum after ſtratum will be taken away, juſt as it would happen if we had a menſtruum capable of diſſolving only the ſuperficial

 layer

layer of an onion without acting upon the others.

CLIX. Before I concluded positively that the gastric juice of this bird does not soften bone at all, I determined to observe its effects when it is at liberty to act without any obstacle; for it is possible, that its efficacy might be impaired by passing through the cloth. I therefore took a piece of the same thigh bone from the thickest part, and worked it into a sphere by the lathe, to prevent the angles injuring the fine coats of the stomach; it was then given to the falcon. My purpose was to observe whether as it was dissolved it was also softened.

It continued five days in the stomach without becoming in the least tenderer. The shortening of its diameter shewed that it was lessened in bulk. Meantime the falcon threw up the sphere once or twice a day, according as he was supplied with food; for, as I have observed with respect to other birds of the same class (CXLVIII), he did not vomit indigestible bodies till he had digested the other contents of the stomach. To cause indigestible substances to remain in that cavity after other bodies are digested, I gave him fresh food; for experience having taught me to judge, when that period was approaching, I was

was ſure to attain my purpoſe; ſince when the crop is full of food, the contents of the ſtomach cannot be evacuated through the mouth. By this contrivance the falcon was made to retain the globe twenty-two ſucceſſive days. It is ſcarce worth while to obſerve, that it was not ſoftened, ſince the inability of the gaſtric fluid to produce this effect has been ſufficiently proved before; but the remarkable diminution it underwent deſerves to be noticed. The ſphere was at firſt four lines and an half in diameter, and when it had been thirty-five days and ſeven hours in the ſtomach it meaſured only a line and about a third; it preſerved its form perfectly; the ſame may be ſaid of its poliſh; there was not a furrow, nor an indentation, nor an aſperity of any ſort upon the ſurface. This ſmoothneſs is, I think, a clear proof, that the ſtomach of this ſpecies has no triturating power, otherwiſe the globe would have ſuſtained ſome injury from the friction and impulſes of ſo many tin tubes as were introduced into the ſtomach during its continuance there.

CLX. Let it not however be imagined, that bones of a texture leſs compact require ſo much time to be diſſolved; this was very far from being the caſe. My falcon would eat a whole pigeon at once, for birds of this kind when

they take any large prey, always fill themſelves quite full, and then continue ſeveral days without food. My falcon refuſed the entrails, the tips of the wings, and the beak; the reſt he devoured with the utmoſt greedineſs. But no bone or fleſh was ever vomited, nor did any thing paſs out at the vent in the form of bone or fleſh; the excrements now, as well as at other times, conſiſting of a ſemifluid matter, partly white and partly black. When dry it might be reduced to an impalpable powder by rubbing between the fingers. This animal therefore digeſted not only the fleſh, but the bones of a pigeon, and that in the ſhort ſpace of a day; for at the expiration of this time it would eat a ſecond pigeon.

CLXI. While I was examining the manner in which the falcon digeſts bone, ~~I~~ was ſtruck with a thought that had never occurred to me during the whole train of the foregoing experiments; it was to enquire whether the gaſtric liquor beſides bone is alſo capable of digeſting ſome other animal ſubſtances, ſuch as the enamel of the teeth, the tougheſt tendons, and horn. With this view I encloſed two inciſors from the lower jaw of a ſheep in a tube, which the falcon retained three days and ſeven hours. Wherever the enamel did not

not extend they were corroded and waſted, but the other parts were uninjured, and as brilliant as at firſt. In four days and an half longer continuance in the ſtomach the fang was nearly diſſolved, but the enamel was perfectly ſound. The teeth were kept two days more in the ſtomach without the tubes, but no further effect was produced; whence it was neceſſary to infer, that the gaſtric juice of the falcon is incapable of diſſolving the enamel of the teeth; a circumſtance which is not very ſurpriſing, ſince it differs from every other oſſeous ſubſtance.

CLXII. I have elſewhere obſerved, that birds of prey, and conſequently falcons, vomit the feathers of the birds which they eat (LIX); it is therefore evident, that the gaſtric fluid cannot digeſt them. The ſmell emitted by burning feathers ſhews, that they reſemble horn in their nature; it was therefore reaſonable to ſuſpect, that corneous ſubſtances would not be diſſolved in the ſtomach, a ſuſpicion which was verified by the event. Some pieces of ox's and ſheep's horn were as uſual concealed in fleſh, and given to the falcon. In a few days they were thrown up entire and uninjured. I have remarked, that the internal coat of the ſtomach in gallinaceous fowls is not tender and yielding, as

as in many animals, but firm and cartilaginous (XXXV, XLVII, XLIX, L). Having frequently obſerved, that when burned it exhales an odour very much like feathers and horn, I ſuppoſed that it would in like manner elude the action of the gaſtric fluid, which really happened not only in the thick coats of turkeys and geeſe, but in the thin ones of pigeons, blackbirds, and quails. When I gave my falcon the whole ſtomach of any of theſe fowls, the other coats were ſoon digeſted, but the cartilaginous remained entire.

In tendons the reſult was different; for my experiment I choſe an ox's *tendo achillis*, one of the tougheſt tendons that is to be found in animal bodies. It was hung to dry in ſummer for ſeveral weeks, and thus became ſo hard, that a keen knife would hardly cut it. However, the gaſtric liquor of the falcon diſſolved it both when it was encloſed in tubes, and looſe in the ſtomach.

CLXIII. Moſt ſhoes have the upper leather of calf-ſkin, and the ſole of ox's hide. Both theſe ſubſtances are very readily digeſted by carnivorous animals when freſh: this at leaſt is the caſe with the falcon; but the contrary happens when they have been tanned. Another fact has warned me how cautious we ought to be in forming general rules in phy-

ſics.

ſics. Who would not have concluded from the laſt experiment, that every other kind of leather is alſo indigeſtible? Yet the reverſe happened in ſheep-ſkin dreſſed, and dyed yellow. Some liſts of it were encloſed in tubes, and completely digeſted in ſeven hours.

CLXIV. As I had found the gaſtric fluid of other carnivorous animals incapable of digeſting vegetable matters, it was more than probable, that the ſame thing would take place in the falcon. I however thought, that it would be proper to aſcertain this point by experiment, if for no other reaſon, yet on account of the recent inſtance of the uncertainty of analogical arguments (CXLIII). At the ſame time I was deſirous of determining whether digeſtion is the effect of the gaſtric liquor ſolely, as it ſeemed more than probable. The falcon could very well take ſix tubes at a time: four were filled with various vegetable ſubſtances, ſuch as crumb of bread, chick-peaſe, ſlices of pears and apples; in the fifth and ſixth were encloſed mutton and beef. Upon theſe ſubſtances the effects of the gaſtric fluid were exactly the reverſe. The fleſh was totally diſſolved in twenty-ſeven hours, but the vegetables had undergone no alteration. Two freſh tubes, containing in the middle a bit of fleſh, and at the ſides maſticated

cated bread and boiled peaſe and chick-peaſe, decided the queſtion ſtill more clearly. The vegetables were undiminiſhed, but the fleſh, which was ſurrounded by them, was entirely deſtroyed. Thus the incapability of the gaſtric juice to diſſolve vegetables, and its efficacy on fleſh, were fully proved.

CLXV. By means of little ſpunges I procured this fluid ſometimes when the ſtomach was empty, and at others when it contained ſome remains of the food, in which caſe it was always turbid and full of heterogeneous matters, of a cineritious yellow colour, and had not much fluidity. When the ſtomach was empty it was ſufficiently clear, without any extraneous ſubſtance, had an intermediate colour between yellow and white, was very fluid, and had a ſaltiſh and bitter taſte. With this I attempted experiments on digeſtion out of the body, like thoſe I have already ſo often mentioned, The reſult was not different. I obtained the ſolution of various kinds of fleſh by renewing the liquor from time to time, and by applying a heat of thirty deg. the common temperature of theſe animals. With theſe precautions I moreover cauſed nearly the half of a ſplinter of a bone of beef, weighing forty-four grains, to be diſſolved.

CLXVI.

CLXVI. Having made theſe experiments, in my opinion the moſt intereſting the ſubject admits, my next buſineſs was to examine the ſtomach and œſophagus. However, three hours before I killed my falcon, I fed him, in order to ſee what effect is produced upon the food in the craw. It was in part in this cavity, and part had deſcended into the ſtomach, where it had begun to be decompoſed. It was immerſed in the gaſtric fluid, and this incipient digeſtion had the ſame appearance as it has out of the body. The fleſh in the craw, even that which was upon the point of paſſing into the ſtomach, was only a little diſcoloured; this circumſtance ſhews that digeſtion is performed only in the latter cavity, and that in the craw the food is only diſpoſed to be diſſolved more readily.

CLXVII. When a ligature is made below the pylorus, and air blown in at the top of the œſophagus, this part of the alimentary canal reſembles a large inteſtine about five inches long; a little more than half way down the œſophagus is dilated and forms the craw, though we ſhall find, that it has this name improperly, if we compare it with the craws of gallinaceous fowls, which lie at the ſide of the œſophagus, or rather without it; whereas in the falcon the craw is a continua-

tion

tion of that cavity. If we invert and again inflate the œſophagus, and then examine it in a ſtrong light, or with the microſcope, we can perceive an immenſe number of glands from the beginning to the fleſhy faſcia, not excepting the craw. If we blow in freſh air, and obſerve it again with the glaſs, we ſhall ſee the glands, which are of an oblong ſhape, and project a little above the plane of the œſophagus, each emit a drop of liquid; this liquid is ſo viſcid, that one of theſe drops may be drawn out into a filament an inch or more long; it is inſipid to the taſte. The greateſt part of the œſophagus, is full of theſe glands, and is entirely membranous; it only becomes muſcular at the commencement of the faſcia, which in the falcon, as well as other birds, ſeems to conſiſt only of numberleſs follicular glands, and is above an inch in breadth. Theſe follicles are cylindrical, and are all connected by a fine membrane; they have one of their extremities implanted in the external, and the other in the nervous coat of the ſtomach: through the latter, the excretory ducts open and diſcharge the ſame kind of whitiſh and viſcid matter that has ſeveral times been deſcribed as belonging to birds that have ſimilar follicles. Theſe glands and follicles abundantly ſupply the ſtomach with

with fluid; and though it is ſometimes deſtitute of glandular bodies, yet a liquor continually poured into the cavity by exhalent arteries, forms an addition to that which comes from the œſophagus, as is evident from the moiſture which appears upon the ſides when they have been wiped dry ſeveral times.

CLXVIII. The eagle on which my experiments have been made, belongs to the ſpecies called by Mr. Buffon the *common eagle*, becauſe it is found upon moſt of the high mountains of Europe; it was known to Ariſtotle, by whom it is called ΜΕΛΑΙΝΑΈΤΟΣ, or the black eagle Hence it has received the denomination of *Falco Melanpetus* from Linnæus, who refers, with whatever propriety, the eagle and falcon to one family. Though ſome naturaliſts reckon two ſpecies of the common eagle, the brown and the black, I ſhould incline with Buffon and Ariſtotle to ſuppoſe, that there is only one. The difference in colour may depend on the difference of age; for we often ſee animals of the ſame ſpecies, but of different ages, differ in colour. At the time I was in poſſeſſion of my eagle I had an opportunity of ſeeing five others, four dead and prepared, and one living, in the poſſeſſion of the counts Caſtiglioni of Milan, two noblemen equally remarkable

markable for politeneſs of manners and ſkill in natural philoſophy. Theſe animals all differed from each other in colour, ſome being of a black more or leſs deep, and others of a darker or lighter brown; yet they agreed in the eſſential characters of the ſpecies. They were all nearly of the ſame ſize, ſomewhat exceeding that of a turkey-cock; their legs and feet were covered with feathers, the nails were black, the feet yellow, the bill blueiſh, and the baſe was covered with a bright yellow cere: ſuch are the characters which, according to the French naturaliſt, the brown has in common with the black eagle.

CLXIX. The ordinary food of my eagle conſiſted of live cats and dogs, when I could procure them. It eaſily killed dogs much larger than itſelf. When I forced one of theſe animals into the apartment where I kept the eagle, it immediately ruffled the feathers on the head and neck, caſt a dreadful look at the dog, and taking a ſhort flight, immediately alighted on his back. It held the neck firm with one foot, by which the dog was prevented from turning his head to bite; and with the other graſped one of the flanks, at the ſame time driving the talons into the body; and in this attitude it continued, till the dog expired, in the midſt of fruitleſs outcries

outcries and efforts. The beak had been hitherto unemployed, but it was now uſed for making a ſmall hole in the ſkin, which was gradually enlarged; from this the bird began to tear away and devour the fleſh, and went on till it was ſatisfied. I muſt not omit obſerving, that it never eat any ſkin, or inteſtine, or bone, except very ſmall ones, ſuch as the ribs of cats and ſmall dogs. Notwithſtanding this ferocity, and violent impetuoſity in attacking animals, it never gave any moleſtation to man. I, who was its feeder, could ſafely enter the apartment where the bird was kept, without any means of confining its movements, and beheld theſe aſſaults without dread or apprehenſion: nor was the eagle at all hindered from attacking the living prey I offered it, or rendered ſhy by my preſence. As it was not always in my power, or at leaſt in my will, to give it living food (for I had not always dogs and cats at hand; and gallinaceous fowls, which were equally acceptable, were too expenſive) I ſubſtituted fleſh which, though it was not ſo well reliſhed, was not diſagreeable. In general, when it had fleſh at will, it only made one meal a day. I found, by weighing what it eat, that thirty ounces of fleſh ſerved it one day with one another. This ſpecies of eagle

is provided with a very large craw, which of course is the first receptacle of the food; and when it was at liberty to eat its fill, this viscus was generally distended to a larger size than that of a turkey-cock full of grain. It gradually contracts in proportion as the flesh passes into the stomach, just as it happens in gallinaceous fowls.

CLXX. Some of the first times I observed my eagle eat, I was struck by a phænomenon, which constantly recurred whenever it took food. After it had swallowed a few mouthfuls, a thin stream began to flow from each nostril, and to run down the upper side of the beak; at the end they joined, and formed a large drop, which sometimes fell on the ground, but generally passed into the mouth, and was mixed with the food. This drop was continually renewed by fresh supplies from the nostrils, as long as the animal continued to feed, and after that it ceased to appear. This liquor was of a sky-blue colour, had a salt taste, and was nearly as fluid as water. But why does it flow only while the eagle is feeding? and what is its use? It flows at that particular time only, I suppose, because the receptacle in which it is contained is then only compressed; and the pressure arises from the motion of the mouth, or

or the impulſe of the food againſt the palate, near which this receptacle lies. Of the uſe of this fluid, I candidly own my total ignorance. I ſuſpect, however, that as it is mixed with the food, it ſerves, like the ſaliva, to moiſten it, and facilitate digeſtion.

CLXXI. It is commonly thought, and the opinion has the ſanction of the beſt naturaliſts, that birds of prey, and eſpecially eagles, never drink. What I have obſerved is, that when the ſpecies mentioned in the preſent diſſertation, were left even for ſeveral months without water, they did not ſeem to ſuffer the ſmalleſt inconvenience from the want of it; but when they were ſupplied with water, they not only get into the veſſel, and ſprinkle their feathers like other birds, but repeatedly dip their beak, then raiſe their head, in the manner of common fowls, and ſwallow what they have taken up; hence it is evident that they drink. For the eagle it was neceſſary to ſet the water in a large veſſel, otherwiſe, by its attempts to drink, the veſſel was ſure to be overturned.

CLXXII. To collect into one point of view every thing relative to digeſtion, let us examine another opinion, more immediately connected with our ſubject. It is ſaid by

ſeveral celebrated naturaliſts and phyſiologiſts (*a*), that the eagle, when unable to procure fleſh, will feed upon bread. To aſcertain this point, I made various experiments. I firſt ſet before the bird both fleſh and wheaten bread; and finding that it ran towards the fleſh, without even caſting a look upon the bread, I ſet only the latter before it, and this after a day's faſt, when it muſt have been preſſed by hunger; I did not however attain the end I had in view, and therefore kept it faſting for another day, but ſtill to no purpoſe. When the bread was ſet near it, it would juſt look at it, and then turn its eyes towards ſome other object. When I had prolonged the faſt to the fourth day, the bird ran towards me, as I opened the door of the apartment, but with no other view than to aſk for food; I offered it a piece of bread, but in vain, for, without even touching it, it returned to the place where it ſtood before my coming in. I might have carried the trial ſtill further, but was afraid leſt the animal ſhould ſink under it.

CLXXIII. I therefore abandoned this mode of experiment, and thought it would be better to make the eagle ſwallow ſome bread;

(*a*) *Buffon* Hiſt. Nat. des Oiſeaux. T. 1. *Haller*. T. 6.

for

for it would either be always thrown up, and then it would be reaſonable to infer, that this was an unſuitable kind of food; or in caſe it ſhould neither be vomited, nor voided unaltered along with the excrements, and the animal ſhould ſhew no ſymptoms of uneaſineſs, we muſt conclude that it is digeſted and aſſimilated. I concealed the bread in ſome fleſh, as I had done in my experiments upon the falcon (CLVII), and had recourſe to the ſame expedient, whenever I was deſirous that my eagle ſhould take tubes or other ſubſtances. For though this ferocious bird was exceedingly gentle towards me, who was his feeder, yet it might have been hazardous to irritate it; and that would have been unavoidable, if I had opened the beak, and thruſt bread down the throat by force. The firſt portion of bread which the eagle ſwallowed concealed by fleſh, amounted to half an ounce. Indigeſtible bodies, ſuch as feathers, uſed to be thrown up eighteen, twenty, or, at moſt, twenty-four hours after they were received into the ſtomach. But the bread was not vomited in that period, or a day longer; nor did the excrements appear to be altered or mixed with bread. I then gave the animal a whole ounce, inſtead of half an ounce of bread, none of which was vomited

or voided unchanged at the vent. The ſame thing took place, when the quantity of bread was increaſed to ſix ounces. My laſt experiment upon bread, was to ſubſtitute the cruſt inſtead of the crumb; but the reſult was juſt the ſame; and notwithſtanding the eagle had ſhewn ſo little appetite for this kind of food, its health did not appear to ſuffer. And I was obliged to conclude, that this ſpecies of vegetable is digeſted, and converted into real nutriment, as well as animal matters. I could not therefore refuſe to accede to the opinion of thoſe, who affirm that eagles, when much preſſed by hunger, will feed upon bread, though mine would not touch it.

CLXXIV. But in what manner is bread digeſted in the ſtomach of the eagle? Is it by the gaſtric juices alone, or aſſiſted by trituration? Is any ſuch action exerted by it? In ſhort, what is the immediate cauſe of digeſtion? Theſe queſtions are too cloſely connected with the object of my enquiry, to be paſſed over unnoticed. To begin then with the firſt. Tubes employed in my uſual manner, would determine the mode of digeſtion. And in the preſent caſe alſo, I obſerved what I had before obſerved in ſo many other animals, that trituration had no part in this function, and that it was the ſole effect of the

the gaſtric juices. While the eagle retained the tubes, a ſpace that never uſed to exceed twenty-four hours (CLXXIII), the bread which they contained was completely diſſolved. If they happened not to remain long ſo in the ſtomach, the gaſtric fluid had corroded the bread, and given it a yellowiſh colour and a bitteriſh taſte. Where the action of that fluid had been chiefly exerted, the bread was changed into a gelatinous paſte, which had nothing of its original taſte.

CLXXV. But the tubes ſhewed, that the gaſtric liquor of the eagle diſſolves not only bread but Parmeſan cheeſe. This power, poſſeſſed by a bird properly carnivorous, of digeſting a ſubſtance ſo different from fleſh, induced me to try whether it is capable of producing the ſame effect on other matters, and particularly vegetables. But with reſpect to the latter, I did not find that the efficacy of the gaſtric fluid extended any further than bread; for ſeveral ſeeds of the cerealia, both raw and boiled, did not appear to undergo any alteration in the tubes, or when looſe in the ſtomach. It is ſomewhat ſurpriſing, that this ſhould be the caſe with wheat, when wheaten bread is ſo perfectly digeſted. We ſee at leaſt, that vegetables muſt be triturated be-

fore they can be digested by the eagle, as well as by gallinaceous fowls (XLV).

The foregoing experiments, and the concurring observations of others (CLXXII), shew, that some animals, supposed to be strictly carnivorous because they live always upon flesh, and are provided with the most formidable weapons for seizing and destroying their prey, may yet, under certain circumstances, change their disposition and manners, and become frugivorous. Thus we read of animals naturally herbivorous, as horses, sheep, oxen, gradually quitting their usual aliment, and learning to live upon flesh (*a*). I too can produce a recent instance in a young wood-pigeon, a species of bird which is universally known to feed upon any thing rather than flesh. By dint of hunger I brought it gradually to relish flesh so well that it refused every other kind of sustenance, even grain, of which it is naturally so fond. Such changes, whether effected by design or accident, will not excite the smallest degree of surprize in those who know, that of the various kinds of food used by man and animals, the gelatinous part supplies the nutriment, and that this exists alike in vegetables and animals (*b*). The

(*a*) Haller, Phys. T. 6. (*b*) Ib. T. 1.

example

example of the eagle among carnivorous, and of the horſe, ox, pigeon among frugivorous animals, do not however warrant us to conclude, that the former can be univerſally converted by art or chance into the latter, and reciprocally; for, on the other hand, Reaumur's kite (CXVI): and my owls and falcon (CLVI, CLXIV, CLXVI) were incapable of digeſting vegetable ſubſtances (*a*); not that theſe ſubſtances are unfit for affording them nouriſhment, but becauſe the gaſtric

(*a*) Mr. Batigne, in his critical reflections on the experiments of Reaumur, pretends, that we are not to conclude, becauſe vegetables undergo no change in the ſtomach of the kite, that the gaſtric liquor has no action upon them. He ſuppoſes, that its inefficacy aroſe from the vegetables not having been previouſly maſticated. *Premiere Reflexion ſur les Experiences de M. de Reaumur.*

But in this Mr. Batigne is miſtaken. After I had compleated my diſſertations on digeſtion, I procured a kite of the ſame ſpecies as that of Mr. Reaumur, and had it therefore in my power to repeat and vary his experiments. I conſtantly found, that bread, grain, &c. were thrown up unaltered, both when encloſed in tubes and looſe in the ſtomach, though they had been previouſly well maſticated. This fact agrees with my obſervation on the falcon, of which the gaſtric liquor could not digeſt maſticated crumb of bread. I will add, that an owl, fed with chewed bread alone, died upon the fourth day; and upon diſſection, the bread was found in its ſtomach undigeſted. It is therefore evident, that the incapability of the gaſtric liquor of ſome animals to digeſt vegetables does not ariſe from the want of previous trituration or maſtication, and that this fluid is eſſentially unfit for diſſolving ſuch ſubſtances.

liquor

liquor is incapable of decompoſing them, and extracting the nutritious jelly.

CLXXVI. With reſpect to the ſecond queſtion, whether the ſtomach of the eagle triturates its contents? I think I have abundant proof, that it poſſeſſes no ſuch power. Not to mention the numerous tin tubes that remained ſo long in it without receiving the ſlighteſt injury, I can ſafely affirm, that I could never perceive the ſmalleſt contuſion upon the grain (which I gave the bird naked in order to try whether it could digeſt it) (CLXXV), whether raw or boiled; in which caſe, the ſmalleſt compreſſion or impulſe would have left evident marks upon the ſurface. Theſe facts are confirmed by the following obſervation: I took ſome ſtrips, about a line in breadth and three inches in length, of exceedingly thin ſheet lead, and rolling them up in the form of a ſpiral, introduced them along with ſome pieces of fleſh into the ſtomach of the eagle, in which they continued eighteen hours. The leaſt force would have ſufficed to deſtroy the ſhape of theſe ſtrips, and being totally inelaſtic, they would preſerve whatever alteration or diſtortion they might receive from preſſure or percuſſion. However, when thrown up they retained their

their ſpiral form; a clear proof that they had not been ſubjected to violence of any kind.

Let it not however be ſuppoſed, that I mean to exclude motion entirely from the ſtomach of the eagle. Having frequently found foreign ſubſtances within the tubes, and fixed in the perforations, I could not but ſuppoſe, that they had been driven into them by ſome force, and this force could be no other than the agitation of the ſtomach, which was either extrinſical, and produced by the adjacent viſcera, or the periſtaltic movement by which the food is expelled through the pylorus. I only aſſert, that the ſtomach of the eagle has no action capable of breaking and triturating the aliment, as I think I have abundantly proved. It is likewiſe clearly aſcertained, that the gaſtric fluid is the efficient cauſe of digeſtion by the experiments made with bread and cheeſe encloſed in tubes (CLXXV); but this will be more ſatisfactorily ſhewn by the experiments relative to the digeſtion of animal ſubſtances, which I am now to relate.

CLXXVII. The firſt thing I wiſhed to know was what changes fleſh undergoes in the craw, and I had therefore to contrive a method of getting it back at pleaſure. Had this bird been of the ſame gentle and peaceful diſpoſition

poſition as gallinaceous fowls, this would eaſily have been effected; for I ſhould have had only to preſs the portion of fleſh that lay higheſt in the craw upwards with my thumb and fore-finger, and by a continuance of this manœuvre ſhould have brought it out at the mouth. By this ſimple contrivance I have often examined grain from the craw of fowls, pigeons, and ſuch birds; but the ſtrength and ferocioufneſs of the eagle altered the caſe totally. After much reflection, I thought of an artifice eſſentially the ſame as that adopted for gallinaceous birds. I gave my eagle only three or four pieces of fleſh, of which the laſt was tied in the ſhape of a croſs with a fine packthread three or four feet long. The eagle, preſſed by hunger, devoured the fleſh greedily without regarding the ſtring, of which the greater part hung out of the mouth; nor did the bird make any efforts to ſwallow or throw it up. When I thought it time to examine the piece of fleſh I pulled the ſtring forcibly, and the eagle, without growing enraged, opened its beak and allowed me more room for recovering the ſtring, and by conſequence the fleſh that was faſtened to it. Sometimes I uſed conſiderable force, but did not ſucceed, probably on account of the fleſh being got too low down in the craw; in this

caſe, to free the eagle from the inconvenience, I cut the ſtring cloſe to the beak, and gave it ſome fleſh, which carried down the pack-thread before it into the ſtomach, whence it was thrown up in a ſhort time; but I have more frequently ſucceeded in drawing up the fleſh, and thus obtained an opportunity of examining it at leiſure. I never could find, that the craw or its juices were capable of digeſtion. Its weight was nearly the ſame after it was drawn up as before it was ſwallowed, nor did it ſeem as if it was upon the point of being digeſted; the ſurface was only a little tenderer, and had loſt its redneſs; it was penetrated with a fluid that was neither ſalt nor bitter, but quite inſipid. Fleſh therefore is not digeſted, it is only macerated in the craw of the eagle, as grain and graſs in the craw of gallinaceous fowls.

CLXXVIII. We muſt therefore conclude, that the whole proceſs of digeſtion begins and ends in the ſtomach. If then it was of conſequence to know what happens to fleſh in the craw, it is of much greater importance to obſerve how it is altered in the ſtomach. But as the expedient to get the fleſh back, mentioned in the laſt paragraph, would not be of any ſervice here, I contrived another, which anſwered wonderfully well. I encloſed

enclosed the flesh in little nets with small meshes, which were generally vomited empty; but in some there were considerable remains of flesh. The pieces I used for these experiments were globular, and the remains almost always retained that figure. They were thoroughly impreghated with gastric liquor, and had both a bitter and salt taste. The surface was gelatinous; when this was removed, the fibres were easily distinguishable, but were as tender as if they had been boiled, and the colour was changed to a reddish blue. When this stratum of tender fibres was taken off with a sharp knife, that below was firmer and less discoloured, and at the center the flesh did not appear to have undergone any change either in its consistence or colour. It is needless to observe that these experiments prove, that the gastric fluid dissolves flesh. The permanency of the globular form clearly shews, that trituration does not take place, but the whole effect, to repeat it once more, is produced by the gastric liquor, which acts upon the surface, and dissolves one stratum after another till the whole is consumed, as we have seen the same liquor of other animals act as well upon flesh as other substances (LXV, CI).

CLXXIX.

CLXXIX. This laſt experiment rendered it ſuperfluous to try, whether the gaſtric fluid of the eagle will diſſolve fleſh encloſed in tubes. Taking this for granted, I proceeded to enquire, whether digeſtion would be retarded in proportion to the toughneſs of the fleſh with which they were filled. With this view ſome of the liver, of the muſcular fleſh of the thigh and heart, a bit of the brain, and a piece of tendon were encloſed in ſo many diſtinct tubes. They continued thirteen hours in the ſtomach, and the gaſtric fluid acted upon them juſt as I had imagined it would. The tube containing the piece of brain was quite empty; of the liver only a very ſmall part remained; the reſiduum of the muſcular fleſh of the thigh was more conſiderable; that of the heart was ſtill greater; but of the tendon there remained moſt of all. Theſe remains of fleſh and tendon had the ſame appearances as I had obſerved in the balls of fleſh that were introduced into the ſtomach without tubes. The gelatinous matter on the ſurface, the tenderneſs of the fibres lying immediately below, and the conſiſtence of thoſe at the center clearly ſhewed, that the gaſtric juices had acted upon the fleſh encloſed in tubes juſt

as upon what was left loose in the stomach (CLXXVIII).

CLXXX. My next wish was to know whether its activity would be impaired or destroyed by passing through linen before it got to the flesh. With this view, two pieces of the same tendon and heart, equal in size to those employed in the foregoing experiment, were put into two linen bags, and given to the eagle; in eighteen hours they were thrown up. At first the sides of the bags were distended by their contents, but now that which contained the flesh was a good deal collapsed; for half of it was dissolved: the other had more of its original distension; for not above one-third of the tendon was consumed. Upon comparing together the diminution of the substances in the bags and in the tubes (CLXXIX), I found, that in the former case it was less, notwithstanding the bags continued eighteen hours, and the tubes only thirteen. It is therefore evident, that the linen is a greater obstacle to the action of the gastric liquor than the tubes.

CLXXXI. From my experiments upon crows (LXVII) it was obvious to conjecture, that as more folds of linen were wrapped round the animal substances, the action of the gastric liquor would be still less considerable.

derable. I therefore gave the eagle ſix bags, containing each an equal portion of beef; the firſt was ſingle, the ſecond double, and ſo on. The bird retained them twenty-three hours, when they were all vomited at once, as uſually happened to tubes and other indigeſtible matters, which when ſmall are thrown up all at once, and when large one immediately after another. The two firſt bags were empty, and the remainder of fleſh in the four others were larger as the folds were more numerous, ſo that in the ſixth it was the largeſt of all. It had however undergone ſome diminution, and the gaſtric fluid had therefore begun to diſſolve it, notwithſtanding the ſix folds, as appeared from its being impregnated with it, and from the tenderneſs of the fibres, and the change of colour on the ſurface. My next wiſh was to try whether the juices of the ſtomach were capable of penetrating through a denſer ſubſtance; I therefore ſubſtituted cloth in the ſtead of linen, and having put ſixty-eight grains of beef in the bag, tied ſome packthread very tight round its neck. In fourteen hours it was vomited, and being apparently of the ſame ſize as at firſt, it was returned immediately into the ſtomach, where it continued twenty-two hours longer. I

now found that the cloth, notwithstanding its close texture and great thickness which amounted to four-fifths of a line, was thoroughly penetrated by the gastric liquor. The flesh was also moist with it, and appeared, upon being weighed, to have lost twenty-seven grains. Twenty-seven grains had then been dissolved, and as no vestige of them was to be seen in the inside of the bag, it was evident that they must have passed out through the pores of the cloth, and consequently that the gastric fluid is capable of reducing flesh to particles of the utmost tenuity.

CLXXXII. I have before observed, that the eagle devours the smaller bones of dogs and cats along with the flesh (CLIX). When I gave that in my possession a bird, it would also swallow all the bones, except those of the extremities; and as they were not thrown up, there was good reason for believing that they were digested, a circumstance that exactly agrees with my observations on falcons and various other birds (XCVIII, CXLVII, CLIV, CLVIII). But greater certainty was desireable, and this I endeavoured to attain in the following manner: two pieces of the rib of a small dog, each about two inches long, were tied together, and two thigh bones of

a cock;

a cock; this packet was retained twenty-three hours; but the bones were very much altered during that time. The two pieces of rib were reduced to the thinneſs of a membrane; the leaſt violence was ſufficient to break them; they were totally inelaſtic, and had loſt all their marrow. The two thigh bones now reſembled tubes of parchment; they were eaſily compreſſible, and when left to themſelves recovered their ſhape, and after being bent they would become ſtrait again. Upon one of the tibiæ thus waſted and altered there was a very ſingular appearance; about one-fifth was ſtill oſſeous, but tender, yielding to the touch, and much attenuated. It is therefore apparent, that the juices of the ſtomach are capable of diſſolving bone, and that in a ſhort ſpace. I was unwilling to throw aſide theſe bones thus reduced almoſt to nothing, and therefore tying them up in a bundle I gave them again to the eagle, in order to ſee whether they would be entirely diſſolved, or, like a caput mortuum, retain their membranous appearance; but being apprehenſive that this could not be ſo well aſcertained if they were naked in the ſtomach, I encloſed them in a tube. It was retained thirteen hours, and upon examination was entirely empty; it was therefore

 reaſonable

reaſonable to infer, that the gaſtric fluid had now completed the ſolution.

CLXXXIII. The readineſs with which theſe bones, of a texture by no means tender, were digeſted, led me to ſuppoſe, that the hardeſt would not reſiſt the action of the gaſtric liquor. To determine this, I began by giving the eagle a ſphere worked at the lathe out of an ox's thigh bone, of the ſame diameter as that which had been uſed for the falcon, and taken from the ſame individual (CLIX). Upon that occaſion I obſerved, that the falcon did not diſſolve it during the long ſpace of thirty-five days and ſeven hours. In the preſent caſe it was every day vomited, and immediately returned, and in twenty-five days and nine hours it was completely digeſted. The eagle is then capable not only of digeſting the hardeſt bones, but of digeſting them in a ſhorter ſpace than ſome other birds of prey. In the account of my experiments on the falcon I remarked two things, firſt, that its diameter decreaſed without any change of ſhape; ſecondly, that the texture was not ſoftened during the whole time (CLIX). The firſt phænomenon occurred on this occaſion, the ſphere not only maintained its figure, but continued as ſmooth as when it came from the lathe. But with reſpect to the ſecond circumſtance,

cumſtance, there was a wide difference; for notwithſtanding the hardneſs of the bone, the ſurface was ſo ſoft every time it was thrown up, that it was eaſy to pare off with a knife, ſlices as flexible as cartilage. The gaſtric fluid then of the eagle, beſides diſſolving the ſuperficial ſtrata, had penetrated into the ſubſtance of the bone and ſoftened it; an effect which that of the falcon is incapable of producing. Penetrating, however, as it is, it has no action on the enamel of the teeth, any more than that of the falcon (CLXI).

CLXXXIV. We have ſeen how much more ſpeedily the gaſtric fluid of the eagle digeſts bone than that of the falcon; the ſame obſervation may alſo be extended to fleſh. The former bird required thirty ounces a day (CLXIX), the latter was ſatisfied with twelve, and ſometimes with ten. The gaſtric liquor of the one then diſſolves, in an equal ſpace of time, three times as much as that of the other, and conſequently the rapidity of digeſtion in one is triple of that in the other. I ſhould however, upon mature reflection, be inclined to conſider this greater rapidity as apparent, rather than real. The eagle indeed digeſts three times as much fleſh as the falcon in the ſame time, but then the gaſtric juice of the former is far more copious

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than that of the latter; and if we ſuppoſe it to be three times as much, a ſuppoſition very admiſſible, as we ſhall ſoon ſee, every third part will diſſolve a quantity of fleſh equal to that diſſolved by the whole gaſtric fluid of the falcon. The ſame remark is applicable to other animals. With how ſmall a quantity of fleſh is the little owl ſatisfied in compariſon with the eagle, and conſequently how inconſiderable is the ſolution effected by the gaſtric liquor; but then how trifling does the quantity of that liquor appear when we conſider that of the eagle! The ſame reflection will recur when we compare a lamb with an ox, or a hare with a horſe. But with reſpect to the caſe in queſtion, 'I could not deviſe any more effectual means of determining whether the greater effect produced by the juices of the eagle aroſe from the greater abundance ſolely, or in part alſo from its ſuperior efficacy, than to give each of theſe birds a ſmall quantity of fleſh at the ſame time, and obſerve what would be the event. It would either be digeſted by one as ſoon as by the other, and then the ſame efficacy muſt be aſcribed to both; or elſe the eagle would digeſt it more ſpeedily than the falcon, in which caſe the ſmall quantity of fleſh would not allow us to ſuppoſe, that the fluid of the falcon

falcon could not so soon dissolve it on account of its being in smaller quantity, and we should therefore be obliged to conclude, that it is less capable of digesting flesh than that of the eagle. This experiment I have often repeated, not only upon the falcon and eagle, but upon the two species of owls also, and crows, and the result has been, that sometimes one and sometimes another of these birds has digested the small portion of flesh soonest; nor did the eagle at all distinguish itself above the rest. As the difference of time was very inconsiderable, it may be overlooked, and we may safely suppose, that the digestive power of the gastric fluid is nearly equal in these several species, and consequently that the eagle has no advantage over the rest. It may however be objected, that with respect to bone, at least, the prerogative of digestion belongs to the eagle in preference to the falcon, which takes above thirty-five days to dissolve the same sphere which the eagle dissolves in less than twenty-six (CLIX, CLXXXIII). I can adopt this opinion without much reluctance, since there is no inconsistency in supposing, that two menstrua may agree in the effects they produce upon one body, but differ with respect to another; nay, this idea is confirmed by the facility

 with

with which the gastric fluid of the eagle penetrates into and softens bone, a quality which that of the falcon does not possess in the smallest degree (CLIX, CLXXXIII).

CLXXXV. Let us now proceed to shew the great abundance of gastric fluid in the eagle in comparison with smaller birds, such as the falcon, the owl, &c. To procure this fluid I was not obliged, as in other animals (LXXXI), to use small spunges. The eagle supplied me spontaneously. Very soon after it was in my possession I was aware, that along with the tubes a quantity of gastric fluid was thrown up, so that the floor was often quite wet with it. It was easy to devise a method of catching it before it fell on the ground; for the eagle rarely moved from the place where it took food, and therefore generally vomited the tubes on the same spot. Upon this I set a large glass vessel, and thus was enabled to collect a large quantity of liquor, which generally exceeded three-fourths of an ounce a day on those days when the vomiting took place, a quantity which I could not even hope to procure from all the abovementioned birds of prey taken together. What I obtained in this manner was extremely well suited to my purpose, not being adul-

terated

terated with heterogeneous matters; for it was always thrown up when the ſtomach was empty, as I knew by the avidity which the animal ſhewed for freſh food at this time. Its ſmell, which I cannot deſcribe, is not diſagreeable, but very much reſembles that emitted by the gaſtric liquor of other birds of prey. If we except the colour, which in the others is yellow, but in the eagle cineritious, it exhibited the ſame qualities, whether we conſider the bitter and ſalt taſte, the turbid appearance, which is almoſt inſeparable from the one as well as the other, its fluidity, which comes near to that of water, its diſpoſition to evaporate, or the total want of inflammability.

CLXXXVI. The gaſtric juice of the eagle, as well as that of other animals, is capable of digeſting animal and vegetable matters out of the body. It has even produced an incipient ſolution of bone, and an almoſt complete one of cartilage; but the experiments were made in a conſiderable heat; for otherwiſe little or no ſolution took place, and the gaſtric juices of the eagle now only prevented theſe ſubſtances from becoming putrid.

Upon this fluid I made two experiments, to which I had not ſubjected that of other animals.

animals. On a very cold day in winter I expoſed a ſmall quantity in a glaſs, on a window, along with two other glaſſes containing water, in one of which was diſſolved a quantity of common ſalt ſufficient to give it a ſtronger taſte than the gaſtric fluid had. The thermometer ſet beſide the glaſſes ſtood at 5 deg. below 0 (*a*). Of the three liquors the firſt that was frozen was the common water, the next was the ſalt water, and the laſt was the gaſtric fluid. When I carried them into my apartment, where the temperature was three and an half deg. above 0, the firſt that thawed was the gaſtric fluid, next the brine, and laſtly the water. It muſt therefore be ſuppoſed, that this gaſtric juice is capable of reſiſting cold more than common water. As this cannot be attributed to its ſaline principle alone (otherwiſe it would have been ſooner frozen than the brine), it is neceſſary to admit ſome other principle capable of retarding congelation, whether ſpirituous or oily, or of whatever other nature; and the cloſe analogy ſubſiſting between the gaſtric liquor of the eagle and other animals renders it highly probable, that a like principle exiſts alſo in them.

(*a*) Twenty and three fourths, Fahren.

My

My ſecond experiment was the following: having learned from Mr. Levret (*a*), that the juices of the ſtomach have the power of diſſolving the inflammatory cruſt of the blood, I procured ſome of it from a pleuritic patient, and immerſed it in a phial of the gaſtric fluid of the eagle. The event completely anſwered my expectation: for in two days and a half, in a temperature of 15 deg. the cruſt was entirely diſſolved, and converted into a liquid of a dark hue: this can occaſion no ſurprize; for if the gaſtric fluid can diſſolve animal ſubſtances of a far harder texture, ſuch as muſcle, cartilage, bone, out of the body, it will much more eaſily produce the ſame effect upon the inflammatory cruſt of the blood.

CLXXXVII. Here the death of the eagle, which happened ſomewhat more than five months after it had been in my poſſeſſion, put a ſtop to my experiments. I however reſolved to examine the parts that are ſituated internally, the only enquiry relative to digeſtion that could now be made. During the diſſection I found, that this individual was a female; for there were many eggs, ſome ſmaller and ſome bigger, attached to

(*a*) Art d'Accoucher.

the ovaria. It was conſequently much larger and ſtronger than the male of the ſame ſpecies; for it is a conſtant obſervation, that the male in birds of prey is about a third ſmaller and weaker than the female; whereas, in other claſſes, the male exceeds the female in both theſe reſpects (*a*). The inteſtinal canal was full of the uſual folds and convolutions; when ſtretched out at full length, it was about fifty-nine inches long from the begining of the duodenum to the end of the rectum. There is a double pancreas, and each portion is perfectly diſtinct and ſeparate; but the ſame obſervation has been made upon other animals. Both theſe glands are of a blueiſh fleſh-colour, of an oblong ſhape, and ſmaller toward the end. There is a difference in the ſize, one being an inch and an half in length, whereas the other is only an inch and three lines. They lie parallel, are ſituated about five inches from the pylorus, and ſtretched along beſide the duodenum, one on each ſide, and are attached by cellular ſubſtance. At about ſix inches diſtance from the pylorus an apparent cord, tinged internally with a dark azure-colour, lies upon the duodenum. If we trace it

(*a*) Buffon. l. c. T. 1.

back-

backwards, we find it gradually enlarged, and at laſt inſerted in the gall-bladder, which, in ſhape and ſize, reſembles a wood-pigeon's egg. From what has been before obſerved (LXXXIV, CXV), it is eaſy to gueſs the uſe of this cord; it is the duct through which the bile paſſes from the bladder into the duodenum. If the gall-bladder be preſſed gently the cord becomes immediately tinged with a deeper azure, and the liquor runs into the duodenum: if we open that gut, the upper part is found tinged with a greeniſh azure bile. Upon wiping it away, the entrance of the duct becomes viſible, and freſh bile runs into the duodenum when the preſſure is renewed. The gall-bladder lies towards the right lobe of the liver, but is not covered by it. The bile is rather denſe, and has a ſtrong bitter taſte.

CLXXXVIII. When I inſpected the ſtomach I was aſtoniſhed at its ſmall ſize, when compared with the crop. The latter cavity is capable of containing thirty-eight ounces of water, whereas the ſtomach can ſcarce hold three. We muſt therefore ſuppoſe, that the great quantity of fleſh devoured by this voracious bird paſſes ſlowly from the craw to the ſtomach, in proportion as it is digeſted

digeſted and expelled into the inteſtines. Hence it is eaſy to comprehend how a ſingle meal may ſerve ſeveral days; for a large prey will be equivalent to ſeveral ſmaller ones. I cannot give a better idea of the ſhape of the ſtomach, than by comparing it to a man's leg and foot. At the point of the toes lies the pylorus, the foot reſembles the bottom of the ſtomach, and the leg the upper part. The fleſhy faſcia full of follicular glands, which in other birds, whether granivorous or carnivorous, is ſituated juſt above the ſtomach, in the eagle is contained within its cavity, and makes up the ſuperior and larger half. The internal coat of this faſcia is ſo thin and delicate, that it tears upon being ſlightly rubbed with a cloth. We come next to the nervous coat full of an infinite number of pores, out of which, when preſſure is made, iſſues a viſcid, cineritious, and inſipid liquor. Upon removing this coat theſe pores appear to be the excretory ducts of the follicles, of which one extremity adheres to this, and the other to the muſcular coat; next the laſt mentioned lies the external coat, which appears to be membranous. The glands are cylindrical, a line and one-fourth long; they are tied together by a number of membran-

ous

ous filaments. This ſhort deſcription ſhews the entire reſemblance between the faſcia of the eagle and other birds. The four coats paſs on to the inferior part of the ſtomach, and extend to the pylorus. The muſcular coat ſeemed to merit a diſtinct examination. It conſiſts of two ſtrata. That which lies next the nervous coat is formed by fleſhy faſciculi, of a lively red colour, running in a longitudinal direction. The other is of a paler red colour, and the fibres interſect thoſe of the other coat at right angles, and of courſe run tranſverſely. Notwithſtanding their nearneſs they are perfectly ſeparate from each other, like the rings of certain worms, particularly of the earth-worm, which they moreover reſemble in their blueiſh fleſh-colour. Theſe two thin ſtrata doubtleſs cauſe the various motions of the ſtomach, of which the effects have appeared in ſome of the experiments related above. This coat is one-fourth of a line in thickneſs; upon the faſcia it is thinner, and I could only find the tranſverſe ſtratum; whence it ſeems probable, that the motion of the ſtomach chiefly takes place in the lower part, which has no, at leaſt no apparent, glands; but as a thin tranſparent liquor oozes out on ſlight preſſure, as in

in the ſtomach of birds belonging to the ſame claſs (XCIII, CLI, CLXVII), we muſt conclude, that it abounds in ſmall arteries, which perform the office of glands.

CLXXXIX. The death of my eagle happened a few hours after it had taken food, but I could not diſcover the cauſe. Moſt of the fleſh was in the craw, and a little only had deſcended into the ſtomach. It lay at the bottom near the pylorus, but ſhewed no appearance of being digeſted, whether on account of the morbid condition of the animal, or becauſe it had but juſt fallen into the ſtomach. It was ſoftened by the gaſtric juices, that taſted very bitter, which, as well as its yellow hue, was owing to the regurgitation of the bile into the ſtomach, and theſe qualities were more apparent in the vicinity of the pylorus. The fleſh in the crop was not altered in conſiſtence or colour, except that which lay in contact with the ſides; this was a little diſcoloured and ſomewhat tenderer than at firſt, circumſtances that agree with what was ſaid at the cloſe of the CLXXVIIth paragraph.

Upon emptying, inſerting, and then inflating the craw, the ſurface was covered with a multitude of ſmall drops, which, when united by

by ſome flat body paſſing over them, formed a fluid as tranſparent and thin as water; it ſeemed to have a bitteriſh ſavour. Upon inſpecting the places whence the drops aroſe, they ſeemed ſo many points, which the microſcope ſhewed to be minute pores. Hence it appeared, that every part of the crop abounds with theſe perforations, which I had no heſitation in ſuppoſing to be the excretory ducts of a multitude of glands lying between the coats, as I had alſo found in the craws of other birds (XLIX, L, CLXVII). In ſearch of them I diſſected away the internal coat, which, in thickneſs and ſtrength, reſembles the nervous coat of the ſtomach, of which perhaps it is a continuation. But neither in the ſubſtance, or between it and the muſcular coat, did I find any appearance like glands. All that I could perceive, when I held the internal coat againſt the light, was the pores already mentioned, that looked like lucid points. Nor did the muſcular or the external coats, which laſt is membranous, contain any glandular body. I was therefore obliged to conclude, that the fluid oozing out in the form of numberleſs drops upon the internal ſurface of the craw is ſecreted, not by glands, but by arteries too ſmall to be

 viſible.

visible. The rest of the œsophagus is also full of these pores, and the same fluid issues out from them; no small part of which must run into the cavity of the stomach, and contribute to the formation of the gastric menstruum, which is composed of this and the proper fluid of the stomach, of the bile, and the pancreatic juice.

DIS-

DISSERTATION V.

THE SUBJECT OF DIGESTION IN ANIMALS WITH MEMBRANOUS STOMACHS CONCLUDED. THE CAT. THE DOG. MAN. WHETHER DIGESTION TAKES PLACE AFTER DEATH.

CXC. THE great difficulty with which cats are made to ſwallow tubes, and the facility with which they vomit them, hindered me from making experiments upon this irritable animal in the manner I could have wiſhed. Among, however, a vaſt number of unſucceſsful trials I have once or twice ſucceeded, and thus have been enabled to illuſtrate one chief object of my enquiries, I mean the efficient cauſe of digeſtion. I have uſed every effort to oblige this animal to ſwallow bread and fleſh, their ordinary food,

enclosed in tubes, and in two individuals, one an adult, and the other a young one, have forced them into the stomach. Both were killed, one after having retained tubes filled with flesh nine, and the other with bread five hours. The former were found near the pylorus. The outside was wet with gastric juice, the grating at the ends was entire, as also were the tubes, upon which there did not appear any bruise or other injury. Two of the tubes were empty, the third contained a bit of the size of a lentil-seed macerated in the gastric fluid. The center preserved the colour, consistence, and taste of flesh; the surface was changed into a greyish jelly of a bitterish taste.

The tubes containing bread having remained only five hours in the stomach, were not empty. It had been chewed before it was put into the tubes, by which it was moulded into the shape of cylinders six lines and three-fourths long. These cylinders were not completely dissolved, a portion about four lines long remaining towards the middle of the tube, which was externally gelatinous, but internally retained the characters of bread. This experiment then furnishes an irrefragable proof, that the gastric fluid, as well in the cat as in other animals with membranous and

and intermediate ſtomachs, is the efficient cauſe of digeſtion independently of any triturating power.

CXCI. If the ſtomach be inverted and then inflated, it will be covered with humidity, though care ſhould have been taken to wipe it dry. This humidity will appear repeatedly after the ſtomach has been freed from it, a phænomenon common, as we have ſeen, to various other animals. It is not poſſible to diſcover the pores from which this fluid iſſues by the aid of a microſcope, nor can any glandular bodies be perceived in the coats, or the intervals between them; but when the ſtomach is held againſt the light, and examined with a glaſs of great magnifying power, a number of bright flat meſhes or eyes appear through the coats. I could not however determine the nature of them, notwithſtanding I conſidered the different parts of the ſtomach with ſome attention.

CXCII. My ſucceſs with dogs was much greater than with cats. I could make them take more tubes without being liable to the inconvenience of having them vomited. I could not however force them down the œſophagus, for this operation was attended with the ſame danger as in the falcon and eagle; whenever I attempted it, the animal uſed all

its efforts to bite me. But as they would ſwallow them ſpontaneouſly, like thoſe birds, I had only to conceal them in pieces of fleſh, and throw them upon the floor of the place where the victim of my curioſity was kept. As I always took care he ſhould be hungry, he generally ran towards the fleſh, and ſwallowed it eagerly without maſtication; whereas, the cat would keep it in the mouth, and after chewing it for ſome time, throw out the tubes generally compreſſed by the action of the teeth, and ſwallow the fleſh only.

I repeated the experiment that ſucceeded with the two cats (cxc) upon a dog; the animal took ſix tubes, four full of various kinds of animal ſubſtances, as coagulated blood, lights, muſcle, and cartilage; the two others contained chewed crumb of bread. In fifteen hours the dog was killed, and the ſtomach examined; it contained only four tubes; the other two had not been voided, and I ſuppoſed they muſt have paſſed on to the inteſtines, where I found them among the excrementitious matter at the beginning of the rectum. Before I deſcribe the appearances in the tubes, I ſhall ſay a few words of the juices with which the ſtomach abounded. As it contained nothing but the tubes, we may conſider the gaſtric juice as pure. It was

of

of a yellow colour, very bitter, almoſt without ſmell, not ſo fluid as water, and totally deſtitute of inflammability. It evidently conſiſts of two ſubſtances, one very thin, the other viſcid and gelatinous, which was depoſited after ſtanding a few hours. If the veſſel was ſet near the fire the clear part evaporated, and left a cruſt which was formed by the gelatinous matter.

The two tubes that had paſſed out of the ſtomach were empty, if we except ſome excrementitious matter that had got in through the meſhes of the grating. Of the other four three were empty, nor could I diſtinguiſh which had contained bread and which fleſh. The tough and compact cartilage alone filled part of the tube in which it had been put, but as far as I could judge by my eye, it was half waſted. It exhibited the ſame appearance as on a former occaſion; it was imbibed with gaſtric fluid, and had acquired the ſame taſte, at leaſt on the ſurface. It was ſo ſoft, that it ſeemed to approach more to the nature of membrane than cartilage.

CXCIII. The reſult of this experiment does not coincide with an obſervation in the *Prælectiones Academicæ* of the illuſtrious Boerhaave, publiſhed with a commentary by

 Haller.

Haller. The paſſage is ſo important, that I muſt quote it as it ſtands in the original. "Receptum eſt in hominum opinione quod oſſa animalibus ſubigantur; cum Helmontianis olim ſenſit Boerhaavius; ut vero certior eſſet, curam adhibuit, ut obſervaret, quid cibis fieret in ventriculis animalium valde cibos coquentium, & experimento cognovit non ſubigi. Dedit cani devoranda inteſtina animalium, famelicus erat, affatim deglutiit, ſubegit minime & per extremum inteſtinum pendula miſere poſt ſe traxit. Dedit famelico cani oſſa butyro inuncta, reddidit furfura, neque quidquam diſſolvit niſi quod in aqua diſſolvi poteſt. Dedit carnes, reddidit fibras carnis exſuccas. Dedit ligamenta, ea poſt tridium nihil mutata egeſſit (*a*)."

I reſerve till hereafter what I have to ſay on the famous problem concerning the digeſtion

(*a*) It is a general opinion that animals digeſt bone, and Boerhaave once entertained it in common with the followers of V. Helmont. But in order to be certain, he made the experiment upon a ſpecies of animal endowed with ſtrong digeſtive powers. He gave an hungry dog ſome inteſtine, but found that inſtead of digeſting it, that it tormented him by hanging out of his anus. Bones dipped in butter were alſo given to an hungry dog, but he returned the fragments without diſſolving any thing more than water is capable of diſſolving. When he tried fleſh the fibres were voided with their juices expreſſed, and ligament was voided in three days unchanged.

gestion of bone by dogs, and now confine myself to that part of the experiment that relates to the intestine, flesh, and ligament. I must candidly own, that the different results obtained by Boerhaave and myself surprized me. My surprize increased when I considered, that the substances were loose in the stomach of his dog, and of course more liable to be attacked and dissolved by the gastric liquor; whereas my tubes must more or less impede its access. Upon further reflection it occurred to me, that perhaps the dog was affected by some internal malady, which might alter the properties of the gastric fluid, as in the owl mentioned in the fourth dissertation, of which the gastric fluid was rendered unfit for digestion by too long fasting (CLII). This reflection however was not quite satisfactory, and therefore to clear up the matter, I thought it would be better to repeat Boerhaave's experiment, and give a dog some intestine, in order to see what changes it would undergo in the alimentary canal. A middle-sized dog accordingly eat four pieces of the colon and ileum of a sheep, and at the same time took two tubes, containing each a portion of the same intestines. The tubes were voided before the time I had fixed for killing the animal, for both were found

found among the excrements within about eleven hours after they were ſwallowed. When the tubes were waſhed clean, I found that the pieces of inteſtine were about half digeſted. The ſolvent having acted upon both ſurfaces had reduced their thickneſs conſiderably, but what was left ſtill retained its original ſtructure. I then waſhed the excrements, and diſcovered ſeveral pieces of inteſtine, waſted indeed, as well as thoſe contained in the tubes, yet eaſily diſtinguiſhable.

CXCIV. This experiment does not exactly coincide with that of Boerhaave; it is not however totally repugnant to it, ſince the pieces of inteſtine were not completely diſſolved. My long acquaintance with the circumſtances attending digeſtion gave riſe to a conjecture, which I reſolved to ſubmit to the teſt of experiment. The digeſtion of theſe pieces of inteſtine, ſaid I to myſelf, was not complete in the ſhort ſpace of eleven hours (CXCIII); but may it not be ſo in a longer time? Is not the quantity of ſolution in ſome meaſure proportional to the quantity of time? Does not this appear from undeniable facts related in the foregoing diſſertations?

In order to verify my conjecture, I had only to contrive a method to prevent the inteſtine from

from paſſing ſo ſoon through the pylorus; and this, I conceived, might be done by enlarging the tubes beyond their uſual ſize. I got the laſt-mentioned dog to take three ſuch tubes filled with as many pieces of the large inteſtine of a ſheep, as amounted to half an ounce and four penny-weights. The tubes were concealed in pieces of the ſame inteſtine. The dog, which as uſual, was hungry at the time of the experiment and was ſtill kept faſting, voided ſome excrement in twenty-one hours, and upon minutely examining it, I thought I had ſome foundation for believing, that my conjecture was not fallacious; for though ſome membranous and fibrous fragments appeared among it, which could be nothing but pieces of the inteſtine in which the tubes were concealed, yet they were much more waſted, and much leſs eaſily diſtinguiſhable than in the former experiment (CXCIII), on account of their longer continuance in the body. As the proceſs of digeſtion is leſs rapid in the tubes than in the open ſtomach, I let the dog live twenty hours longer, when the three tubes had remained forty-one hours in the ſtomach. They all three lay cloſe together at the inferior orifice of the ſtomach, wrapped up in ſome bits of rag, which in all likelihood the animal had ſwallowed

ſwallowed before the experiment, and both the tubes and rags were immerſed in gaſtric fluid. I make no mention of this juice, having found it to poſſeſs the properties deſcribed in the CXCIId paragraph. The reader is more intereſted in knowing what happened to the inteſtines contained in the tubes. Nothing could have ſucceeded better than this experiment: two of the tubes were empty, and what remained in the third did not amount to eleven grains; and thus I had the ſatisfaction of finding, as I had conjectured, that the incomplete digeſtion of pieces of inteſtine ſometimes obſerved in dogs, is no proof of the inability of the gaſtric fluid to diſſolve them; it only ſhews, that they have not been long enough ſubjected to its action. Hence the reaſon of Boerhaave's miſtake appears evident. Perceiving ſome inteſtine which he had given to a dog hanging out behind, he concluded that the animal could not digeſt ſuch ſubſtances (CXCIII); whereas from the facts juſt adduced it is obvious, that they had only not continued in the ſtomach a ſufficient length of time.

CXCV. Theſe facts alſo ſhew, that fleſh loſes its fibrous ſtructure in the ſtomach of the dog, and it retains only when it happens to be voided ſoon after it has been ſwallowed. But

But it might be objected by a rigid partizan of Boerhaave, that I have not strictly proved, that the solution extends to the fibres; for they may have been gradually separated from the common mass, and passing out at the pores, and especially through the meshes of the lattice-work, have left the cavity of the tube empty. I therefore thought it would be proper to throw further light upon the subject by a decisive experiment. If pieces of flesh were inclosed in purses of very thick linen, they would either be dissolved and leave no vestige behind them, as by other animals in like circumstances (LXVII, CLXXX, CLXXXI); and in this case we must infer, that dogs are capable of dissolving flesh completely, or else the fibres would remain in the purses, and then we should be obliged to agree with Boerhaave, that the digestion of flesh by dogs consist in expressing the juices and converting them into chyme, while the solid parts remained unaltered. But along with the flesh I subjected harder and more tenacious animal substances, such as tendon and ligament, to the test of experiment. Six bags of very thick linen were given to two dogs; four containing four different sorts of flesh, viz. beef, veal, horseflesh, and mutton; and the two others tendon and ligament of an ox. Each bag

bag contained a quarter of an ounce; and it is to be obſerved, that the contents were not cut into ſmall pieces. Being apprehenſive leſt theſe bags, though of ſome bulk, would paſs through the pylorus before the time for examining them, I tied to each a bit of dry ſpunge. They continued four days in the ſtomachs of the two dogs; but fearing leſt ſo long a faſt might be hurtful to the animals, and of courſe diſturb the proceſs of digeſtion, I fed them ſeveral times, though rather ſparingly. At the expiration of the time juſt mentioned, I killed, and immediately opened them. The experiment ſucceeded juſt as I could have wiſhed; for all the bags were in the cavity of the ſtomach. Suſpecting that they might have been torn by the teeth of the dogs, I took particular care to examine them, but they were whole, and the four firſt upon being cut open were as empty as if they had never contained any fleſh, but of the tendon and ligament there remained about the ſize of a hazle-nut; there was no hole in either of the bags. The tendon appeared, upon being weighed, to have loſt three-fourths, and the ligament above one half. I examined with particular attention, whether this diminution of bulk and weight aroſe from the expreſſion of the juices, but the contrary was evident; for

for they were as pulpy and moiſt as at firſt. Hence I had every reaſon for concluding, that the gaſtric fluid had really attacked and diſſolved the ſolid parts, ſo as to enable them to paſs through the pores of the linen. The ſame thing had happened to the fleſh. The ſolution was ſtill further confirmed, by the condition of the external ſtrata of the tendon and ligament, which were become ſo tender as to be torn by the ſlighteſt violence. I was thus fully convinced of the efficacy of the gaſtric fluid of the dog in diſſolving the fibres both of fleſh, tendon, and ligament, though the proceſs is leſs rapid in the latter on account of their greater tenacity and harſhneſs. That Boerhaave's dog ſhould void the ligaments unchanged on the third day (*ea poſt triduum nihil mutata egeſſit*, CXCIII), if by this expreſſion he means that they retained the nature of ligament, and it ſeems incapable of any other interpretation, I have not the ſmalleſt ſcruple in believing, having ſeen the ſame thing in a ligament that had been four days in the ſtomach of a dog. It had indeed undergone a conſiderable diminution, a circumſtance which the celebrated Dutch phyſician would alſo have obſerved if, inſtead of judging by his eye, he had taken the precaution

caution of weighing it before it was ſwallowed, and after it had been voided.

CXCVI. We now come to conſider whether dogs are capable of digeſting bone; a problem which, if we may rely upon the obſervations of ſeveral celebrated phyſiologiſts and phyſicians, would appear to be decided in the negative. We have already ſeen that Boerhaave's dog, after having eaten bones dipped in butter, produced no other change upon them than ſimple water would have done (CXCIII). This he alſo endeavours to confirm by the following remark: "Deinde in ſtercore canino, quod *Album Græcum* vocant, fragmenta oſſium pene non mutata reperiuntur, & fit mera oſſium raſura, quæ dentibus canis adroſit, exſuccorum & in unam maſſam reductorum." It appears from ſome notes on this paſſage and from his great work (*a*), that his illuſtrious diſciple, Albert Haller, adopted the ſame opinion. Dr. Pozzi alſo aſſerts in his work quoted above (XIII), that dogs do not digeſt bone. Of the two experiments which he relates, the following appears the moſt concluſive. He gave a dog that had been kept faſting for five days three bones which, though dry, the animal ſwallowed for the ſake of the butter with which

(*a*) El. Phyſ. T. 6.

they

they were anointed. One of the bones weighed three ounces, another two, and the third one. In three days they were voided, and had only loſt ſix grains.

Such are the ſtrongeſt arguments adduced by phyſiologiſts againſt the vulgar opinion. This opinion however found in Reaumur an able advocate, one who eminently poſſeſſed the difficult art of making experiments with ſucceſs. Of the ſeveral productions by which he has ſignalized himſelf, none have contributed more to his reputation, than the two beautiful memoirs on digeſtion, which I have ſo often quoted with applauſe. To illuſtrate the preſent curious and intereſting ſubject he made the following experiment (*a*). Two compact cylindrical bones, each ſeven lines long and two in diameter, were given to a ſmall bitch, which was killed in twenty-ſix hours. The bones that were ſtill in the ſtomach were diminiſhed in bulk, and it appeared to him that ſeveral laminæ were removed. They had moreover acquired the flexibility of horn, though they were at firſt rigid and inelaſtic. Hence he infers, that they had been in part diſſolved by the gaſtric fluid.

(*a*) Mem. 2.

CXCVII. Having noticed the experiments of others, let me relate my own. In the ſtomach and inteſtines of the dog, mentioned in the CXCIId paragraph, I found ſeveral pieces of bone. They ſeemed to belong to ſome quadruped, probably a ſheep, and muſt have been eaten before the dog came into my poſſeſſion. I did not weigh them, but as far as I could judge by inſpection, they amounted to above ſix ounces. Upon waſhing and then examining them attentively, I perceived ſeveral ſcars and longitudinal furrows, of which I doubted whether they were produced by the gaſtric liquor or the teeth of the dog; beſides, many of the angles and edges were evidently blunted, at the ſight of which the idea of what happens to the hardeſt bodies in a muſcular ſtomach recurred. I moreover obſerved, that theſe places were not ſo hard as the thicker parts of the bone. But theſe phænomena only ſuggeſted doubts, which I reſolved to diſſipate by the light of experiment. I therefore filled ſome tubes with pieces of bone, and gave them to a dog. The bones were of various kinds and degrees of hardneſs: the tubes, which were two in number, were put into a bag of linen, in order to prevent the bits of bone from getting out. To allow the gaſtric juices a proper time for producing

ducing their effects, the dog was suffered to live for seven days, and during this time was fed moderately. One of the tubes, though they were rather large, had passed into the cœcum, and was surrounded by feculent matter; the other remained in the stomach. They were neither of them empty, but their contents, which at first weighed three-fourths of an ounce and eighteen grains, now amounted only to four penny-weights and seven grains. All the angles and edges were destroyed. The softest bones had suffered most. They could now be easily cut in the thin places with a knife. The thinnest parts of the bone were dissolved and had passed through the bag, not a vestige of them remaining. This experiment proves two propositions, viz. that the digestive powers of the dog act upon bone as well as flesh, though the latter, on account of its softness, is more speedily dissolved, and that the gastric juices are the sole efficient cause of digestion.

CXCVIII. This experiment was repeated three times, and the result was essentially the same; but there occurred two circumstances that deserve to be noticed. One of the dogs produced only a small diminution of the bones in eight days, though it was fed plentifully, and seemed to be in perfect health the whole

 time.

time. This ſhews, that little or no effect being produced upon the bone, which ſometimes happens, as in the caſes alledged by Boerhaave and Pozzi (CXCVI), is no proof of the inefficacy of the gaſtric fluid of this animal; it only ſhews, that the digeſtive powers are unequal; nor ought this to excite our ſurprize, as the ſame thing is obſervable in our own ſpecies.

The other remarkable circumſtance, to which I alluded, is the reverſe of the preceding. Among the bones given to one of the dogs, were two dentes inciſores from the upper jaw of a ſheep. It has been already obſerved, that the enamel of the teeth receives no injury from the gaſtric fluids that are capable of diſſolving the hardeſt bones, ſuch as thoſe of the eagle and falcon (CLXI, CXXXIII); yet the gaſtric fluid of the dog in queſtion, damaged this compact ſubſtance. I have now before me the two teeth, which I keep as a curioſity. The enamel of one is corroded in two, and of the other in three places; the five cavities are above a line long, and penetrate to the nucleus of the bone. The roots of the teeth were almoſt entirely deſtroyed. The powerful menſtruum of the ſtomach, had made greater havock among the other bones that were encloſed along with the

the teeth; the excavations as they were wrought in a tenderer ſubſtance were more conſiderable. Upon comparing this phænomenon with the furrows mentioned in the CXCVIIth paragraph, I have no doubt but they were occaſioned by the gaſtric ſolvent. It deſerves to be remarked, that in the caſe where the enamel of the teeth was deſtroyed, the linen bag had not ſuſtained the ſmalleſt injury, though the ſolvent neceſſarily paſſed through it: nor is this to be wondered at; for we have inſtances of many gaſtric fluids that are capable of decompoſing the moſt compact animal ſubſtances, though they do not produce any effect on the ſofteſt vegetable matters (CXLVI, CLVI). This is alſo true of chemical menſtruums; the nitrous acid diſſolves the hardeſt calcareous ſtones, but leaves the moſt friable gypſum and clay untouched.

CXCIX. Though my experiments on dogs deciſively prove, that digeſtion is the effect of the gaſtric fluid alone; yet it was proper to enquire, whether the ſides of the ſtomach have any motion during digeſtion, and what that motion is? There were two ways of making this enquiry; mediately, that is, by the effects; and immediately, that is, by opening the abdomen and inſpecting the ſtomach.

With respect to the first mode, though I was certain that the stomach of the dog had no considerable motion, because neither the tubes nor the bags had sustained any injury; yet in order to see whether it has any motion at all, I gave a dog some thin tubes open at the ends, which were therefore liable to be compressed by the smallest violence. But I could not find the least contusion upon them, after they had been three days in the stomach. The inspection of the tubes, however, presented a phænomenon which shewed, that the sides of the stomach had not been inactive all the time. Upon opening this viscus I found a mass of hairs, which were of a different colour from those of the dog, and could not therefore have been swallowed while the animal was licking itself. They must have belonged to some other animal that had been devoured by the dog, before it fell into my hands. Many of these hairs had likewise got into the tubes; which must have been effected by the action of the stomach.

CC. I opened five living dogs, taking care not to wound the stomach. This operation was performed soon after they had taken food; for I presumed that the muscular fibres, irritated by the distension, would contract more evidently at this time. The

stomach

ſtomach of the firſt was perfectly quieſcent when it was left to itſelf. But when the point of a knife was drawn over it, the parts that were touched and thoſe that were adjacent immediately contracted, and then returned to their former ſituation. Upon throwing round a ligature above the cardia and below the pylorus, and taking the ſtomach out of the body, I thought I perceived a ſlight periſtaltic motion, but it was of ſhort duration. The contraction and dilatation continued to ſucceed each other in the places that were touched with the knife, or any irritating body, for half an hour. The ſtomach of the ſecond was not only deſtitute of ſpontaneous motion, but was inſenſible to every ſtimulus. In the third ſtomach the periſtaltic motion was very conſpicuous; the contraction began juſt below the ſuperior orifice, and proceeded with a gentle undulation to the pylorus, and the dilatation regularly followed. This ſpectacle laſted for ſeven minutes. And I could reſuſcitate the motion by irritating the upper part of the ſtomach, but it continued only a little while. The periſtaltic movement did not appear on the ſtomach of the fourth dog, but irritation would excite it. And it was in this caſe confined to the ring or circular band correſpond-

ing to the place where the ſtimulus was applied. This band contracted gently, and the diameter of the ſtomach was ſenſibly diminiſhed; in a few minutes it dilated juſt as ſlowly. In the fifth ſtomach the periſtaltic motion was as apparent as in the third; it laſted ſome minutes longer, and when it had ceaſed in all the other parts of the viſcus, a band juſt above the pylorus continued theſe alternations. The contraction was ſo conſiderable, that the oppoſite ſides of the ſtomach almoſt touched each other; but all theſe motions were exceedingly ſlow, nor did the ſides of the ſtomach ever dilate or contract ſuddenly or forcibly.

CCI. At the ſame time I examined the ſtomach of ſome cats in the ſame manner. The reſult was exactly alike. A gradual movement of contraction and dilatation, beginning at the upper end and extending to the lower, was generally perceptible.

All theſe experiments, and the reader will find ſimilar ones in Haller, though made with a different view (*a*), clearly ſhew, that the motion of the ſtomach of the dog and cat are not capable of triturating the food, but calculated to carry it ſlowly from the ſu-

(*a*) Mem. ſur les part. irrit. & ſenſib. T. 1.

perior

perior to the inferior orifice, and thence expel it into the duodenum.

From the great number of dogs that were ſubjected to theſe experiments I collected a large quantity of gaſtric fluid, and found it as capable of producing an incipient digeſtion out of the body, as that of the other animals mentioned above, both of boiled and raw meat, and likewiſe of ſeveral vegetables. It was however neceſſary to apply a pretty ſtrong heat, and to change the liquor ſeveral times, as in other inſtances.

CCII. Blaſius, in his laborious and accurate anatomy of the dog, ſays, that the internal coat of the ſtomach is compoſed of a congeries of glands (*a*). My opportunities of aſcertaining this have been frequent. I have examined it with my naked eye and with the microſcope, but could never perceive any glandular appearance. Upon wiping it dry and preſſing it, it was covered with an aqueous exſudation, but I could not diſtinguiſh the pores from which this exſudation iſſues. I have examined ſeveral pieces with the ſolar and the ſimple microſcope, and in ſome perceived a vaſt number of lucid points, while in others there appeared nothing of this kind. I then examined the back part, which is con-

(*a*) Anat. Anim.

tiguous to the nervous coat, and immediately ſaw, that it is compoſed of a congeries of oblong particles, of a pale fleſh-colour, cloſely compacted together. Theſe are probably the glands of Blaſius; but I cannot affirm that they are really glands, not having been able to diſtinguiſh the characteriſtic marks of glandular bodies in them. But however this may be, it is certain they are deſtined to tranſmit a fluid into the ſtomach; for whenever they are preſſed, the above-mentioned exſudation appears upon the internal ſurface. And this fluid may be expreſſed ſeveral days after the ſtomach has been taken out of the body.

I have before ſaid, that the pores from which the gaſtric liquor iſſues are inviſible; but the parts contiguous to the pylorus muſt be excepted, in which they are very conſpicuous. Upon comparing the fluid that thus oozes out with that which is collected in the ſtomach when it is opened, we ſhall find a very ſtriking difference. The latter, as we have ſeen above, is yellow, bitter, and ſomewhat gelatinous (CXCII). But the former has not one of theſe properties, being colourleſs, inſipid, and very fluid. Hence it is evident, that the gaſtric liquor of the dog, that liquor which is the efficient cauſe of digeſtion,

gestion, consists, as in other animals, of several different principles, viz. of saliva, of the œsophageal juice, of that which is peculiar to the stomach, of the pancreatic juice, and of bile.

CCIII. To complete my researches on animals with membranous stomachs, it remained to examine that of Man. One may indeed draw very plausible inferences concerning human digestion, from observations on the other species of this numerous class; especially from birds of prey, the cat and dog, which resemble us so much in the structure of the stomach. But analogical arguments are probable indeed, but not conclusive. And it is an object of much higher importance to attain certainty in Man than in animals. In the writings of antient and modern physicians no topic is more frequently discussed, yet there is little else beside supposition: direct experiments upon Man are entirely wanting, and their researches are illuminated only by the twilight of conjecture, and supported by precarious hypothesis. If therefore it was necessary on other occasions to have recourse to experiment, on the present it was absolutely indispensible. Upon reflection it appeared, that the principal experiments were reducible to two heads, viz. to procure human

man gastric fluid, in order to examine it in the manner that of animals has been already examined; and to swallow tubes full of various vegetable and animal substances, in order to see what changes they undergo in the stomach. I will candidly own, that the latter kind gave me some apprehension. The histories of indigestible substances occasioning troublesome symptoms, and being vomited after a considerable time (*a*), occurred to my mind. I also recollected instances where such bodies had stopped in the alimentary canal. Other facts however where the result was contrary, and of more frequent occurrence, gave me confidence. Thus we every day see the stones of cherries, medlars, plums, &c. swallowed and voided with impunity. This consideration at last determined me to make a trial with as great caution as possible.

CCIV. I swallowed in the morning fasting a linen bag, containing fifty-two grains of masticated bread. All the following experiments were made under the like circumstances. I retained the purse twenty-three hours without experiencing the smallest inconvenience, and then voided it quite empty.

(*a*) Haller, Phys. T. 6.

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The ſtring uſed for ſewing and tying it was entire, nor was there any rent in the bag itſelf. Hence it is plain, that it had not received any damage either in my ſtomach or inteſtines. The fortunate reſult of this experiment gave me great encouragement to undertake others. I immediately repeated it with two of the ſame bags, with this variation, that one was double, and the other had three folds. My motive obviouſly was to ſee, whether theſe additional folds would impede digeſtion. The bags were voided in twenty-ſeven hours, and the double one was empty; but the other ſtill contained a ſmall quantity that had yet the characters of bread.

CCV. From vegetable I proceeded to animal ſubſtances. In a ſingle linen bag ſixty grains of boiled pigeon were encloſed, and in another the ſame quantity of boiled veal; both previouſly maſticated. The purſes were voided in eighteen hours and three-quarters, and the fleſh was entirely conſumed. Inſtead of ſixty I next took eighty grains, of which the bulk was not ſo great as to make me apprehend any danger from its ſtopping in the œſophagus, and ſtill leſs from its not getting out through the pylorus, as at that time it muſt of neceſſity be very much diminiſhed in bulk. The fleſh had been previouſly boiled and

and maſticated. I retained it twenty-nine hours, at the expiration of which time there remained eleven grains undiſſolved. This fleſh differed in appearance from that which is taken undigeſted out of the ſtomachs of animals. The ſurface of the latter is gelatinous, but the former was as void of ſucculency as if it had been ſet under a preſs. This appearance, which is analogous to that of the bread in the preceding experiment (CCIV), made me ſuſpect, that perhaps the human ſtomach might poſſeſs a power of compreſſing its contents, though others of the ſame ſtructure are deſtitute of ſuch a power. I therefore determined to bring this ſuſpicion to the teſt of experiment.

CCVI. Finding that I could digeſt dreſſed meat that had been maſticated, I wiſhed to know whether I was capable of digeſting it without maſtication. I ſwallowed eighty grains of the breaſt of a capon, encloſed in a bag. The bag was retained thirty-ſeven hours. So long a ſpace had produced conſiderable effects, for it had loſt fifty-ſix grains. The ſurface of the remainder was dry, but the internal fibres appeared to be more ſucculent. Digeſtion ſeemed to have gone on uniformly, for the piece retained its original ſhape.

CCVII. I

CCVII. I next wiſhed to know whether this dryneſs of the ſurface would be obſerved in raw as well as dreſſed fleſh. I did not doubt but I ſhould digeſt it in this ſtate more or leſs ſpeedily; for the human ſtomach is adapted to the digeſtion of the one as well as the other, whole nations living upon raw fleſh, and raw fiſh being eaten in ſome maritime countries; not to mention that oyſters, cockles, &c. in the ſtate they are taken, are among the delicacies of the elegant and luxurious, though a food of difficult digeſtion. I took faſting fifty-ſix grains of raw veal and as much beef, encloſed in two bags, which were returned about the middle of the next day. Of the veal, as it was the tenderer, there remained fourteen grains, and of the beef twenty-three. In both there was the ſame dryneſs on the ſurface as if the bags had been wrung, or preſſed by ſome external violence.

CCVIII. As then this phænomenon is conſtant, are we to ſuppoſe, that the digeſtion of fleſh and bread, which is produced by the gaſtric fluid within the bags, is aided by the triturating power of the ſtomach? Does any ſuch power exiſt at all? I could deviſe no better means of ſolving theſe doubts, than by obſerving what happens to animal and vegetable

table ſubſtances encloſed in tubes. Should they either not be at all or imperfectly digeſted, we muſt infer, that there was wanting ſome circumſtance either neceſſary, or at leaſt expedient; and we might preſume, that it is trituration. I was then under the neceſſity of ſwallowing tubes. Having ſuffered nothing from the former experiments, I entered upon theſe without much apprehenſion. Inſtead of tin I had my tubes made of wood, fearing leſt the reſidence of the metal in the ſtomach and bowels ſhould be productive of bad conſequences, although I never perceived any in other animals. The gaſtric fluid had never corroded it, the ſurface was only turned black. My wooden tubes were five lines in length and three in diameter. The ſides were, as uſual, perforated with a great number of holes, in order to allow free ingreſs to the juices of the ſtomach, along the whole length of the tubes, as well as at the ends. To prevent the entrance of the fœculent matter during their paſſage through the long track of the inteſtines, they were encloſed in linen bags, a precaution not always employed upon other occaſions of the like nature. At firſt I took a ſingle tube, containing thirty-ſix grains of boiled veal previouſly maſticated. The tubes was voided empty in twenty-two hours.

hours. The cover of linen was entire, and had prevented any extraneous matter from getting in.

CCIX. This experiment, which is by no means favourable to the doctrine of trituration, induced me to attempt others before I drew any conclusion. As the tube was capable of containing above thirty-six grains, I put in forty-five. I retained it seventeen hours. There was a residuum of twenty-one grains; and now appearances were changed; the veal not only had its natural succulence, but the surface was soft and gelatinous, the center alone remaining fibrous. The jelly was sweet, its smell was not at all putrid, any more than that of the residuums in the purses. These appearances were observed in three other experiments with boiled, and one with raw flesh of several different kinds. I hesitated not to conclude, that in Man, as well as numberless other animals, the gastric fluid digests the food without the concurrence of trituration. It is indeed not possible that it should concur; for I have direct proofs, that no muscular action capable of producing such effects is ever exerted by the human stomach. Among the wooden tubes employed in these experiments, I procured some to be made so thin that the slightest pressure would crush

them to pieces; and though I frequently used them, not one was ever broken. If I took off the linen cover, which was always entire, and examined them with ever so much attention, I could never perceive the smallest fissure.

CCX. These perfectly coincide with the following facts. Cherries and grapes are said to be voided entire (*a*). I resolved to ascertain by my own experience the truth of these observations. I first swallowed four unripe grapes, because in that state they have greater firmness. In a day they were all voided with the skin whole; the colour was changed from a greyish white to yellow. I next made trial of ripe grapes, which, as every one knows, burst on the slightest pressure. Of twenty-five which I swallowed eighteen were voided entire, of the other seven the skins only appeared. I made the same experiments with many cherries, as well ripe as unripe, and by far the greater number were voided entire. These experiments, together with those made on the thin tubes, afford the most conclusive evidence, that no triturating force is exerted by the human stomach.

I shall be perhaps asked, what is the cause of the dryness of the fibres, so often observed in

(*a*) Haller, Phys. T. 6.

in fleſh encloſed in the linen bags, which would appear to have been forcibly preſſed (CCIV, CCV, CCVI, CCVII)? Upon conſidering the matter I was led to ſuppoſe, that the inteſtines are more concerned in this phænomenon than the ſtomach. While the bags remain in the ſtomach, the fleſh is converted into a gelatinous matter; for there is no reaſon to believe that this happens in the tubes only, and not in the bags. But when they are protruded into the inteſtines, they muſt be ſurrounded and preſſed by the fœculent matter. Hence the jelly is ſqueezed out, and the fibres loſe their ſucculence. And this, not the action of the ſtomach, I take to be the reaſon why cherries and grapes are now and then burſt.

CCXI. Having thus eſtabliſhed this fundamental propoſition, viz. that the digeſtion of fleſh and bread is produced in my ſtomach by the gaſtric fluid independently of trituration (CCIV, CCV, CCVI, CCVII, CCVIII, CCIX, CCX), I had before me a fine field for experiments that could not fail to ſuggeſt ſome important truth. The neceſſity of maſtication is ſufficiently known. There is, perhaps, no perſon who has not ſome time or other been ſubject to indigeſtion for want of having chewed his food properly. In the

course of my experiments I had ſwallowed ſome maſticated fleſh, and ſome without maſtication; but having never taken care that it ſhould be of equal ſize, I had no term of compariſon, and hence was not certain which was moſt ſpeedily digeſted. I therefore ſupplied this omiſſion in the following manner. I took two pieces from a pigeon's heart, each weighing forty-five grains, and having chewed one as much as I uſed to chew my food, encloſed them in two tubes, and ſwallowed them at the ſame time, but without attaining the end I had in view; for the tube containing the chewed fleſh was voided in twenty-five hours, and the other in thirty-ſeven, both empty. Another experiment made under the ſame circumſtances ſucceeded better, both the tubes were voided in nineteen hours, and I then ſaw how much digeſtion is promoted by maſtication. Of the maſticated fleſh there remained only four grains, whereas of the other there were eighteen left. This was confirmed by two other experiments, one made with mutton, the other with veal. The reaſon is obvious. Not to mention the ſaliva which moiſtens the food and prediſpoſes it to be diſſolved, it cannot be doubted, that when it is reduced to pieces by the action of the teeth, the gaſtric fluid penetrates more readily,

readily, and by attacking it at more points, diſſolves it more ſpeedily than when it is whole. This is true of menſtrua in general, which always diſſolve bodies ſooner when they have been previouſly broken in pieces. This is alſo the reaſon why in other experiments, maſticated bread and dreſſed fleſh were more readily diſſolved than unchewed bread and raw fleſh. The boiling had made it tenderer, and conſequently diſpoſed it to allow ingreſs to the gaſtric fluid.

CCXII. It is an opinion common among modern phyſiologiſts, that fleſhy fibres, tendon, cartilage, and bone loſe their juices in the human ſtomach, but that the ſolid parts are not diſſolved or digeſted. With reſpect to fleſhy fibres, I muſt differ from them, having clearly proved the contrary by experiment (CCV, CCVIII, CCXI). As I could bring the other ſubſtances to the ſame teſt, I would not neglect an enquiry of ſo much importance. I at firſt took membrane encloſed in a tube without maſtication or diviſion, weighing about ſixty-five grains. The tube was voided in thirty-two hours, and preſented the following appearances: The membrane was entire, but ſeemed thinner and ſhorter. It weighed only twenty-eight grains. This diminution, however, was not

a ſufficient proof of the ſolution of the ſolid parts; it might depend upon the privation of the fluids. It was therefore proper to return it into the ſtomach, and wait the reſult. The membrane was voided in fifteen hours; it was ſtill in one piece, but exceedingly reduced, weighing now only five grains. This petty remainder I ſwallowed a third time; the tube was voided in twenty-two hours, and was now completely empty. I afterwards obſerved the ſame phænomena in membranes of greater thickneſs and tenacity; and I once digeſted the aorta of a calf after it had been boiled. The only difference I could perceive was, that the compacter membranes required more time to be diſſolved.

CCXIII. I made experiments upon cartilage and tendon at the ſame time. To avoid diſguſting the reader by too particular a recital, I will only mention the bare reſults. The cartilage was more ſpeedily diſſolved than the tendon, the former being totally conſumed in eighty-five and the latter in ninety-ſeven hours. Both were taken from an ox, and had been previouſly boiled for half an hour.

CCXIV. Bones ſtill remained, and I ſubmitted ſome both of a hard and ſoft texture to experiment. The latter were completely diſſolved,

diſſolved, and required about the ſame time as cartilage. But the former underwent no perceptible diminution, though it continued upwards of eighty hours in my ſtomach. I likewiſe ſwallowed a naked ball of hard beef bone three lines in diameter, and in thirty-three hours voided it undiminiſhed.

It is therefore certain, that the ſtomach is capable of digeſting not only muſcular fibres, but membrane, tendon, cartilage, and even bone itſelf, provided it is not too hard; though moſt phyſiologiſts and phyſicians have been led to adopt a contrary opinion by obſerving, that theſe ſubſtances are evacuated unaltered. But this is no proof that they are indigeſtible (for if they had made the experiment on themſelves, and weighed the ſubſtances, they would have obſerved a waſte), it only ſhews, that they are not ſo ſoon digeſted as other kinds of food, which are diſſolved in a few hours; whereas, membrane, tendon, cartilage, &c. require ſeveral days, on account of their tenacity and hardneſs.

Let no one ſuppoſe, that my ſtomach, being ſtronger than common, is capable of digeſting what that of others cannot digeſt. I own, with concern, that it is weak, as is uſual in thoſe whoſe purſuits condemn them to a ſedentary and unwholeſome way of life.

My ſtomach digeſts food ſo ſlowly, that I cannot ſtudy for five or ſix hours after a ſparing dinner, and am liable to indigeſtion whenever I feed more plentifully than common.

Before I quit this ſubject let me obſerve, that though I have mentioned the gaſtric juices as the efficient cauſe of digeſtion in the experiments on myſelf, yet I mean not to exclude thoſe of the inteſtines from their ſhare. We know, that the ſmall inteſtines complete the proceſs of *chylification*, which is but begun in the ſtomach. I muſt therefore allow, that the digeſtion of animal and vegetable ſubſtances in the bags and tubes is perfected in the inteſtines. But this is not in the leaſt repugnant to the reſult of thoſe experiments that ſhew the human ſtomach to be deſtitute of any triturating force, and digeſtion to be the effect of the gaſtric fluid alone, though the fluid which is ſecreted by the ſides of the ſmall inteſtines may complete the proceſs.

CCXV. In the CCIIId paragraph I remarked, that the chief experiments on man were reducible to two heads, thoſe which relate to the natural proceſs, as it may be obſerved by means of tubes and ſuch contrivances, and thoſe which relate to artificial digeſtion,

digeſtion, provided the gaſtric juices can be procured. Having treated the former of theſe diviſions as well as circumſtances would permit, it remained for me to make ſome enquiries relative to the ſecond. It was firſt neceſſary to deviſe a method of procuring the gaſtric fluid. The firſt idea that ſtruck me was to ſearch for it in dead bodies, but after examining ſeveral ſtomachs I was obliged to abandon this ſearch; for they were either without any fluid, or elſe what they contained was ſo turbid and ſo much adulterated with heterogeneous matters, that it would by no means ſuit my purpoſe. Nor were the little ſpunges, which had ſerved ſo well in animals, better adapted to the preſent occaſion. Two ſpunges would not ſupply me with a ſufficient quantity, and I could venture only to ſwallow two tubes at once, for fear of forming an obſtruction in my ſtomach. Beſides, the juice thus procured would have been very impure, on account of the heterogeneous matters that the tubes muſt neceſſarily have imbibed during their paſſage through the inteſtines.

There remained only to obtain it by exciting vomiting while the ſtomach was empty. To effect this, I choſe rather to tickle the fauces than drink warm water, as in this caſe

the gaſtric fluid muſt have been diluted. In this manner therefore, before I took meat or drink, I procured in two mornings a quantity ſufficient for a few experiments, of which the reſult ſhall be related below. I could have wiſhed to have made a greater number, but the diſagreeable feelings occaſioned by the act of vomiting, the convulſions of my whole frame, and more eſpecially of my ſtomach, that continued for ſeveral hours after it, left upon my mind ſuch a repugnance for the operation, that I was abſolutely incapable of repeating it, notwithſtanding my earneſt deſire of procuring more gaſtric liquor.

CCXVI. I was therefore obliged to content myſelf with what theſe two vomits afforded me. The firſt time it amounted to an ounce and thirty-two grains. It was frothy at its being thrown up, and ſomewhat glutinous. After it had been at reſt a few hours and depoſited a ſmall ſediment, it was as limped as water. It was a little ſalt to the taſte, but not at all bitter. It did not, either when thrown on the fire or brought near a candle, ſhew any token of inflammability (*a*). It evaporated

(*a*) From this and the LXXXIſt, CXXIIId, CXLIXth, and CLXXXVth paragraphs we may collect, that the gaſtric juices both of man and animals are deſtitute of inflammability. I made

evaporated in the open air, and when I put fifty-two grains into a veſſel and ſet it on hot coals, it emitted a thick ſmoke. Another ſmall portion, weighing eighty-three grains, was put in a phial, which was cloſed with a ſtopple to prevent it from evaporating. It did not change colour or taſte, nor did it acquire any bad ſmell; notwithſtanding it was kept above a month in the hotteſt ſeaſon of the year. I thus employed about one half, the remainder was uſed for an attempt to obtain artificial digeſtion. It was put into a glaſs tube two inches long, ſealed hermetically at one end, and very narrow at the other; I then introduced a ſmall quantity of maſti-

made theſe experiments, becauſe Reaumur thought that that of his kite was inflammable, which quality Dr. Batigne imputes to the bile, a fluid conſiſting principally of oil *(premiere Reflexion ſur les Exper. de Reaumur)*. But were this true, the gaſtric juices of moſt of my birds ought to have taken fire. As all mine are contrary to Reaumur's ſingle experiment, I ſhould ſuſpect, that what he obſerved was owing to accident. His experiment was the following: To take away the ſmell of putrid fleſh, which one of his tubes had acquired, he ſet it upon ſome burning coals, when immediately there iſſued a flame from the inſide that laſted above a minute (Seconde Mem.). But it is eaſy to perceive, that this might have been owing to ſome fat of the encloſed fleſh adhering to the tube. I am more confirmed in this ſuſpicion from having obſerved, that the gaſtric fluid of a kite, ſuch as Reaumur's, mentioned in a note to paragraph CLXXV, was not more diſpoſed to take fire than the other gaſtric juices which I examined.

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cated boiled beef, and ſtopping the tube with cotton, ſet it in a ſtove cloſe to a kitchen fire, where there was a conſiderable heat, though not perhaps exactly equal to the temperature of my ſtomach. By the ſide of this tube I placed another, containing the ſame quantity of fleſh immerſed in water. The appearances in both were the following: In twelve hours the fleſh in the former began to loſe its fibrous ſtructure, and in thirty-five it had ſo far loſt its conſiſtence, that when I attempted to lay hold of it, it ſlipped from between my fingers. But though to the naked eye it appeared to be reduced to a pultaceous maſs and to have loſt its fibrous texture, yet the microſcope rendered the fibres viſible; they were however reduced to a great degree of minuteneſs. After this ſemifluid ſhapeleſs maſs had continued two days longer in the gaſtric fluid, the ſolution did not ſeem to have made any further progreſs, and the reduced fibres were ſtill juſt as apparent. The fleſh did not emit the leaſt bad ſmell, while that immerſed in water became putrid in ſixteen hours, and grew worſe and worſe the two following days. It loſt in ſome meaſure its fibrous ſtructure, as always happens during putrefaction; but this appearance did not

proceed

proceed ſo far as in the other portion, for the fibres were entire on the third day.

CCXVII. I vomited the ſecond time more gaſtric fluid, and was now enabled to examine it again as I had done before; and it appeared to poſſeſs exactly the ſame properties. In order to determine the influence of heat two tubes were filled with it, and ſome fleſh was immerſed as before (CCXVI). One of the tubes was placed in the ſtove, and the other left in the open air. In the former the fleſh was juſt as much diſſolved as in the preceding experiment; but in the latter the ſolution proceeded no farther than when water was employed (CCXVI). There was however no putrid ſmell, though the fleſh was left immerſed in the gaſtric fluid ſeven days.

Before I conclude this account, I muſt mention a circumſtance that happened the ſecond time I procured gaſtric liquor by vomiting. Four hours before I ſubmitted to this diſagreeable operation, I had ſwallowed two tubes filled with beef, one of which was thrown up; the fleſh was thoroughly ſoaked in the fluid of the ſtomach, and the ſurface was ſoft and gelatinous; it had moreover waſted from fifty-three to thirty-eight grains. This experiment proves, that there takes place a conſiderable degree of digeſtion in the ſtomach,

ſtomach, before the food paſſes into the inteſtines.

CCXVIII. We may now ſafely lay down ſome general conſequences concerning digeſtion in Man and animals. In the experiments on birds with muſcular ſtomachs, we have ſeen how trituration diſpoſes the food to be digeſted. Hence Nature has furniſhed that claſs with gaſtric muſcles of ſufficient power to effect this neceſſary preparation. But we have likewiſe ſeen how digeſtion, which conſiſts in the tranſmutation of the aliment into chyme, is the effect of the juices alone with which the ſtomach abounds (Diſſ. I).

We next proceeded to birds with intermediate ſtomachs, ſuch as crows and herons, and found, that in them digeſtion was owing to the gaſtric fluid alone (Diſſ. II).

We next conſidered animals with membranous ſtomachs, a claſs ſo numerous and various, that it comprehends almoſt every family of living creatures; it includes the inhabitants of ſalt and freſh water; amphibious animals, as the frog, the newt, and water-ſnake; reptiles, as the viper, the landſnake, and many others; quadrupeds, as the cat, the dog, the horſe, the ox; birds, as

birds

birds of prey: to this catalogue Man himſelf is alſo to be added.

In ſeveral of theſe animals we have ſeen the neceſſity of previous trituration, as in the ruminating order and in Man; in them it is produced by the teeth, as in gallinaceous fowls by the muſcles of the ſtomach. But in others, as in the frog, the newt, ſerpents, and birds of prey, it has no ſhare in the proceſs of digeſtion. But in the latter, as well as the former caſes, we have ſeen how the food is diſſolved and digeſted by the gaſtric fluid (Diſſ. III, IV).

In every order of animals, Nature, always uniform in her operations, employs one principle for the performance of this vital function. Hence ſhe has ſo copiouſly furniſhed the œſophagus and ſtomach with glands, follicles, and other contrivances that anſwer the ſame end, whence continually flow the juices ſo neceſſary to the life of Man and animals. Theſe juices agree in many properties, but the difference of effect ſhews, that they differ in others. In the frog, the newt, ſcaly fiſhes, and other cold animals, the gaſtric fluid produces digeſtion in a temperature nearly equal to that of the atmoſphere. But the gaſtric fluid of hot animals is incapable of diſſolving the aliment in a degree of heat

heat lower than that of the animals themſelves. There is alſo a difference in celerity of action, and in efficacy. In celerity, becauſe the food in hot animals is digeſted in a few hours; whereas, in the oppoſite kind it requires ſeveral days and even weeks, particularly in ſerpents. In efficacy, becauſe the gaſtric juices of ſome animals, as the gallinaceous claſs, can only diſſolve bodies of a ſoft and yielding texture, and ſuch as have been previouſly triturated; while thoſe of others, as ſerpents, the heron, birds of prey, the dog, decompoſe ſubſtances of great tenacity, as ligament and tendon, and of conſiderable hardneſs, as the hardeſt bone. Man belongs to this diviſion; but his gaſtric fluid ſeems to have no action on the hardeſt kind of bones. Further, ſome ſpecies, as birds of prey, are incapable of digeſting vegetables. But Man, the dog, the cat, crows, &c. diſſolve the individuals of both kingdoms alike. In general theſe juices produce their effects out of the body, as the numerous inſtances of incipient digeſtion under this circumſtance, both with the gaſtric fluid of animals and Man abundantly ſhew.

CCXIX. Having thus brought into one point of view the principal circumſtances relative to the efficient cauſe of digeſtion, let us

us compare them with what has been moſt plauſibly written upon this topic ſo intereſting to the phyſician. The opinion that prevails chiefly in the ſchools of Europe is that advanced by Boerhaave, who has in truth done nothing but reconcile the opinions that had been propoſed at different times before him. He obſerves, in the firſt place, that the various ſolid and fluid ſubſtances which ſerve for food, being received into a cloſe, moiſt, and warm veſſel, muſt, according to the nature of each, ſooner or later begin to ferment or putrefy. There are alſo various fluids continually running into the cavity of the ſtomach, viz. the ſaliva, the œſophageal liquor, that thin tranſparent fluid which is ſecreted by the gaſtric arteries, and a viſcid humour ſecreted by glands in the ſtomach. If we conſider the properties of theſe ingredients, and moreover take into the account the remains of the food which ſerve as a ferment, the air which produces an inteſtine movement of the integrant parts, the heat which excites this heterogeneous maſs, we ſhall find, that the aliment will be macerated, diluted, attenuated, diſſolved, determined to an incipient fermentation, and in ſhort, impreſſed with the primary principle of vitality. Thus it is that Boerhaave explains the di-

 geſtion

gestion of soft food. With respect to that of a firmer texture, imagining, that the causes above recited are insufficient to explain the digestion of them, he has recourse to the triturating power of the stomach, produced by the action of the muscular coat, and the pulsation of the aorta and the other adjacent arteries; the nervous fluid, which perhaps flows into the stomach more copiously than elsewhere; and lastly, the continual and strong compression of the diaphragm and abdominal muscles. In consequence of these additional causes, the food in the first place, will be broken down into a pulp, and acquire a cineritious hue; secondly, the fibres, tendons, cartilages, &c. will be deprived of their juices while they retain their cohesion; thirdly, from vegetable and animal substances thus dissolved, will be produced a fluid resembling those of the human body.

CCXX. Thus has this celebrated physician explained his ideas concerning digestion in his Institutions. He supposes, that there are two principal agents in this vital function, viz. the different fluids that are collected in the stomach, and the mechanical action of that organ; the secondary agents are heat, air, the nervous fluid, the remains of the food, and an incipient fermentation.

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With reſpect to the gaſtric fluid, his ideas were indeterminate and unſettled. On comparing this paſſage with his Prælections it will appear, that he conceived that it acted in the ſolution of the food like a ſimple diluent, as water heated to the ſame degree. But facts without number related above ſhew, that it does not act in this manner, but as a real ſolvent. That the ſolution is more ſpeedy and effectual than that obtained by mere water, appears from experiments equally numerous. Moreover, this fluid does not diſſolve ſoft and yielding ſubſtances only, but the hardeſt and moſt tenacious, contrary to Boerhaave's opinion.

With reſpect to trituration, the attentive reader will eaſily anticipate my anſwer. However remarkable the effects produced by the mechanical action of muſcular ſtomachs may be, intermediate and membranous ſtomachs have no ſuch power. I have made particular obſervations on the ſtomach of the dog, which ſo nearly reſembles that of Man, and it never appeared to have any motion ſufficient to break down the food. This was not only proved by thin tubes receiving no injury, but by inſpection of the ſtomach during the time of digeſtion (CXCIX, CC). The reader will find ſimilar proofs taken from the effects pro-

duced by my own ſtomach, in the CCIXth and CCXth paragraphs. Theſe direct arguments ſhew the inſufficiency of the Boerhaavian hypotheſis. It is beſides eaſy to ſhew its falſity, by examining the foundation on which it reſts. He deduces the triturating power from the action of the muſcular coat and the contiguous parts; but this coat is ſo thin in membranous ſtomachs, that its effects muſt needs be inconſiderable. Nor is the preſſure of the adjacent parts of much importance, at leaſt in the cat and dog; for upon opening the abdomen and feeling the ſtomach, I perceived nothing but the pulſation of the arteries, as I had before done in ſome birds with muſcular ſtomachs (XXXVIII). But this pulſation does not compreſs the ſtomach. I likewiſe perceived by my touch, that this viſcus is affected by the vibrations of the neighbouring arteries; but the effects of theſe vibrations are not more conſiderable than the pulſation of its own arteries. The whole ſtomach was lifted up, and depreſſed by the motion attending reſpiration. The periſtaltic movement was alſo general in ſome caſes; but the former did not produce contraction, and the contraction produced by the latter was gentle, and incapable of triturating the aliment.

aliment. It could only agitate, and ſo diſpoſe it to be more readily diſſolved.

CCXXI. Heat, I readily agree with Boerhaave, in conſidering as a co-operating cauſe. My experiments prove its great importance. Though the gaſtric fluid is not inflammable (LXXXI, CXXIII, CXLIX, CLXXXV, CCXVI), yet it is diſpoſed by warmth to inſinuate itſelf into digeſtible ſubſtances, and reduce them to that gelatinous matter which ſerves immediately for nutriment. The ſame obſervation is applicable to menſtrua in general.

I willingly admit, that particles of air, while they are extricated from the food among which they are entangled by means of the ſaliva, contribute to its more ſpeedy ſolution.

But I cannot ſo readily allow, that digeſtion is promoted by the nervous fluid flowing copiouſly into the ſtomach; for its very exiſtence is uncertain, and the hypotheſis is altogether without foundation.

Much leſs can I grant, that the remains of the aliment ſerve any ſuch purpoſe as he aſcribes to them. The great Haller juſtly obſerves, that our appetite and digeſtion are good only when the ſtomach is empty (*a*). I have had ſeveral opportunities of ſeeing this

(*a*) Phyſ. T. 6.

confirmed. When I fed a crow, a heron, or a falcon ſparingly, the ſtomach would be empty in ſix or ſeven hours; when they would take food again very greedily and digeſt it completely, as I found upon opening the ſtomach.

Whether an incipient fermentation contributes to digeſtion, according to the opinion of this writer, is a queſtion which ſhall be examined at ſome length in the following diſſertation, as it has been the ſubject of many modern experiments.

Laſtly, I muſt again differ from him with reſpect to fibres of fleſh, membrane, tendon, cartilage, bone, which, in his opinion, are not digeſted in the human ſtomach, but only have their juices expreſſed; for the experiments I made on myſelf prove, that the ſolid parts are really diſſolved, if we except only the hardeſt bones (CCV, CCVIII, CCXII, CCXIII, CCXIV). As Boerhaave endeavoured to reconcile the various opinions of phyſicians concerning digeſtion, he ſeems inclined to adopt in ſome meaſure the notion of thoſe who ſuppoſe, that the office of the ſtomach conſiſts in extracting the juice of animal and vegetable matters, among whom Mr. Hecquet has particularly diſtinguiſhed himſelf. And a note to the paſſage, in which he ob-
ſerves,

ſerves, that the ſtalks of hay are ſtill viſible in the dung of the horſe and the ox, notwithſtanding it is chewed ſo often by the latter, ſtill more clearly explains his idea. I conſidered it as of great importance to enquire, whether the ſame thing happens in animals belonging to other claſſes, which was really the caſe in ſome. We have ſeen, that the two ſpecies of crow above-mentioned are both granivorous and carnivorous. I ſometimes fed them with wheat a little bruiſed, and notwithſtanding they ſeemed to eat it greedily, their excrements conſiſted of dry fragments of this grain. This likewiſe happened when they had eaten tough fleſh. If I put the excrement in water and ſhook it briſkly, the greater part would be ſuſpended, but a little would fall to the bottom; this, upon examination, proved to be the cellular ſubſtance with a few muſcular fibres, of which the particles cohered pretty firmly; the longeſt pieces meaſured about an inch. What remained ſuſpended in the water was more than twice as much as that which fell to the bottom, and ſtill retained the characters of fleſh. Young crows, which digeſt more ſpeedily than the adult (LXIX), do not completely digeſt tough meat. I could eaſily find cellular ſubſtance among their excrement; but when

inſtead of hard they were fed with tender fleſh, and with ſome ſoft vegetable inſtead of wheat, the excrement did not ſhew the leaſt appearance of this ſort.

CCXXII. I made the ſame obſervation upon frogs. As theſe animals generally feed upon inſects, I often found among the excrement, when treated in the way juſt deſcribed, legs, thighs, and wings of locuſts, and the cruſtaceous parts of other inſects.

Leuwenhoeck, upon examining the excrement of the melvel, found, that it conſiſted of filaments reſembling the hairs of the beard cut off by the razor; theſe filaments he ſuppoſed to be the undigeſted remains of the fiſhes which the melvel had eaten (*a*). I can eaſily believe this to have been the caſe, eſpecially as it coincides with an obſervation of my own upon the excrement of the tench, in which, though I could not perceive any fleſhy fibres, yet the fragments of bone were diſtinctly viſible. I muſt however add, that though I have examined the fœculent matter of many other fiſhes with glaſſes of various magnifying powers, I could never diſtinguiſh the leaſt atom that had the characters of animal or vegetable matter. I have

(*a*) Philoſ. Tranſact. n, 152, 1683.

obſerved

observed the same thing in that of nocturnal and diurnal birds of prey. The tough flesh, of which a small part was voided along with the excrement of crows (CCXXI), is entirely digested by the eagle, falcon, and owl. This observation may be extended to a multitude of birds of various kinds, of which, though I have preserved the names in my journal, to avoid prolixity I forbear to enumerate them. Serpents, though so slow of digestion, dissolve their food so completely, that not a vestige of any organized matter appears in their excrements. This at least I have seen in vipers, water and land-snakes.

Upon comparing my observations upon excrement with those related by Boerhaave and others, I think it must be concluded, that considering animals in general, some substances of both kingdoms are voided unchanged along with their excrements, because the gastric fluid is incapable of dissolving them; but others are voided unchanged, only because they do not continue long enough in the stomach to be digested. This is fully proved by my experiments on flesh, membrane, tendon, and bone, the very substances of which Boerhaave supposed, that the solid parts were indigestible. Flesh taken spontaneously by crows, part of which

is

is voided undigested, but when kept many hours in the stomach is completely dissolved, furnishes another decisive proof of the same proposition.

It is surely not necessary to add, that I do not wish by these strictures to lessen the high reputation of the Dutch Hippocrates. Unprovided with experiments of his own, he collected the opinions of others, and framed a system concerning digestion so ingenious and plausible, that I willingly own that I formerly adopted it, and would not now reject it, if I was not compelled by conclusive experiments.

CCXXIII. I will conclude this dissertation, with some remarks on a problem closely connected with researches concerning the efficient cause of digestion. Mr. Hunter, one of the best English anatomists of the present age, frequently found in the dead bodies which he opened that the great curvature of the stomach was considerably eroded, and sometimes entirely dissolved. In the former case, the edges of the wound were as soft as half-digested food, and the contents of the stomach had got into the cavity of the abdomen. He observes, that such a wound could not have existed in life, as it had no connection with the disease, and more frequently appeared in persons

persons who died violent deaths. In order to discover the cause of this phænomenon, he examined the stomachs of various animals, both immediately and some time after death. In several he observed the same appearance. Hence he thought he was enabled to assign the cause. He supposes the solution to be owing to a continuance of digestion after death, and that the gastric fluid is capable of dissolving the stomach when it has lost its vital principle. From this discovery he infers, that digestion neither depends on the action of the stomach nor on heat, but on the gastric juices, which he considers as the true menstruum of the food (*a*).

CCXXIV. When Mr. Hunter's short but sensible paper came to my hands, I was engaged in experiments on digestion. I had discovered the primary importance of the gastric fluid in this process, and that it acts out of the body; that is to say, in the dead body. I knew also, that after death this fluid issues from the coats of the stomach. From these data I had little difficulty in believing the fact related by the English anatomist, and adopting his explanation of it: nevertheless it was proper to repeat the experiment. Being un-

(*a*) Ph. Transf.

provided

provided with human ſubjects, I had recourſe to animals. Some were opened ſooner, and others later after death; but among the numbers I inſpected, not one had its great curvature diſſolved, or much eroded. I ſay, much eroded, because I have often ſeen a little eroſion, eſpecially in different fiſhes, in which, when I had cleared the ſtomach of its contents, the internal coat was wanting. The injury was always confined to the inferior part of the ſtomach. If theſe facts are favourable to Mr. Hunter, a great number are againſt him. They do not however deſtroy his obſervations; mine are only negative, his are poſitive; and we know that a thouſand of the former do not deſtroy a ſingle one of the latter, provided it is well aſcertained. I have no reaſon to diſtruſt Mr. Hunter, for his paper has the air of ingenuouſneſs and candour which uſually accompanies truth.

CCXXV. The ill ſucceſs of my experiments did not induce me to abandon the idea of digeſtion after death, it only led me to conſider it in another point of view. If it be true, ſaid I to myſelf, that the gaſtric fluid exerts its action after death, it muſt produce ſome ſolution of the food. Let then an animal be fed and immediately killed, after ſome

time

time let it be opened, and let us ſee whether the food has been at all digeſted. I determined to bring this obvious inference to the teſt of experiment; I therefore kept a raven faſting ſeven hours in order to empty its ſtomach, and then ſet before it an hundred and fourteen grains of beef, which were immediately eaten, and muſt have paſſed into the ſtomach, as this bird has no crop. I then killed it, and as it was winter, put it into a ſtove, where it was left ſix hours. Suppoſing this to be a ſufficient time for the gaſtric fluid to exert its action, I opened the ſtomach, and found the fleſh in the following ſtate. It was impregnated with gaſtric fluid, and was become tender; the colour was changed to a pale red, and the ſurface had a bitter taſte, while the internal parts retained the taſte of fleſh. After the gaſtric fluid was wiped away, it weighed only fifty-two grains; it had therefore loſt above half its weight in ſix hours, or, what amounts to the ſame thing, was above half digeſted. The pylorus, and the duodenum for about an inch, were occupied by an aſh-coloured mucus, which muſt have been the diſſolved part of the fleſh.

At the ſame time I gave another raven, that had in like manner been kept faſting ſeven hours,

hours, an equal quantity of flesh, and killed it in two hours and a quarter. My view was to observe the difference between what had lain six hours in the dead, and two and a quarter in the living stomach, and it was very great; for in this latter case the flesh was totally dissolved, except a little cellular substance, which I have found to be always longer in being digested than the muscular fibres; the mucus was the same as before, only in larger quantity, and occupied more of the duodenum. These two experiments compared together prove two things, first, that digestion continues after death; and secondly, that it is then far less considerable than in the living animal, though in the present instance the heat of the stove, which was about 100° (*a*), must have promoted it not a little. The heat of the living raven did not exceed 30° (*b*).

CCXXVI. Another dead raven was kept five hours in the same stove, after I had forced two dead lampreys, weighing together an hundred and twelve grains, down its throat. One lay in the œsophagus, the other had reached the stomach and was completely de-

(*a*) Two hundred fifty-seven deg. Fahr. Ther.

(*b*) One hundred nine and an half ditto.

composed

ompoſed, while the former was indeed en-
ire, but ſoft and flaccid. This accident
roves, that the gaſtric fluid is capable of pro-
ucing a ſenſible degree of digeſtion at a time
hen the œſophageal juices are inert.

CCXXVII. Theſe experiments were made
n winter. I determined to repeat them the
ext ſummer, becauſe then I could expoſe
he dead animals to a greater heat. Accord-
gly in that ſeaſon ſome bruiſed veal was
iven to two ravens, which were immedi-
tely killed, and left ſeven hours in a window
xpoſed to the ſun. We have already ſeen
ſeveral paſſages, the influence of heat
promoting artificial digeſtion (CXLII,
LXXXVI, CCI, CCXVII). Nor did it now
ppear leſs conſiderable. Each raven had
ten ſixty-eight grains of fleſh, of which
ere was not an atom left entire; it was all
ſſolved into the uſual gelatinous pulp, and
e greater part had paſſed through the py-
rus.

Theſe facts, I think, deciſively prove,
at animals, at leaſt the ſpecies juſt men-
oned, continue to digeſt after death. If
conſider the matter rigorouſly, it will be
oper to obviate a difficulty that may be
rted. However careful we are to kill
the

the animal immediately after it has ſwallowed food, it is certain, that there will be a ſhort interval between the time the food gets into the ſtomach and the death of the animal, and that the gaſtric fluids act upon it during this interval. Moreover, after death they will act for ſome time juſt as in life, ſince the vital heat is not inſtantly extinguiſhed. The digeſtion therefore obſerved in dead animals may, if not entirely, at leaſt in part, be produced by the gaſtric fluid acting during life, and a ſhort time after death.

Nothing could be more eaſy than to aſcertain the juſtneſs of this ſuſpicion, ſince we have only to thruſt a little food into the ſtomach of a dead and cold animal, and obſerve the conſequence. I made the experiment upon a raven that had been dead an hour, and had now only the temperature of the atmoſphere. Forty-two grains of beef cut into pieces were forced into the ſtomach, which was opened after the bird had lain ſeven hours expoſed to the ſun. And here inſtead of pieces of ſolid fleſh, I found only the uſual pulpy maſs, partly in the ſtomach and partly in the duodenum. The ſolution was therefore effected by the gaſtric fluid, independently of the powers of life.

CCXXVII

CCXXVIII. The experiment was repeated upon an owl and a blackbird, which were killed immediately after meat had been given them, and left ſeven hours in a warm temperature. The fleſh given to the black-bird had been cut into three pieces, which together, amounted to eighty-two grains; the owl had ſwallowed half an ounce and ſix grains in one piece. Upon opening the ſtomachs, I found the four pieces; but the ſurface was covered with a ſtratum of mucus, which ſhewed, that the fleſh had been diſſolved.

I thought, that perhaps if the fleſh had remained a longer time in the ſtomach it would be more digeſted; but this did not happen, at leaſt when I repeated the two preceding experiments under the ſame circumſtances, except that the birds were expoſed to the ſun for twenty-two hours, I could not perceive, that the ſolution of the fleſh was carried any further. The entrails emitted a putrid ſmell, but this was not the caſe either with the ſtomach or its contents.

CCXXIX. That I might be warranted in deducing general conſequences, I reſolved to repeat this ſingular experiment upon various claſſes of animals, and therefore had recourſe to fiſhes and quadrupeds. Of the former,

 the

the fiſh-market at Pavia only affords the pike, carp, barbel, tench, eel, and the like; but I took care to procure ſuch as were very freſh. I introduced into the ſtomach various animal ſubſtances, as little fiſhes, bits of veal and beef, frogs, grubs, &c. and opened them after an interval, ſometimes ſhorter and ſometimes longer. I will give in a few words what is ſet down at great length in my Journals. The part of theſe ſubſtances that lay in the œſophagus, a poſition which they often had, was unaltered; this was ſometimes the caſe with that which had got into the ſtomach, but it was generally more or leſs eroded. A circumſtance reſpecting frogs deſerves to be mentioned. The tough ſkin of theſe animals was often deſtroyed, eſpecially at the bottom of the ſtomach; and where it ſtill remained it was ſo much ſoftened, that the ſlighteſt force was ſufficient to lacerate it. Hence it appears, that the gaſtric fluid of fiſhes retains its property of diſſolving fleſh, but in an inferior degree to that of birds, ſince it did not diſſolve ſo much.

CCXXX. The quadrupeds upon which I made theſe experiments, were dogs and cats. After keeping them faſting many hours, I gave them a certain quantity of fleſh, and then

then ſtrangled them without delay. Of three dogs and three cats, two of the former and as many of the latter were expoſed to the ſun for nine hours; the others were left in the ſhade. In the firſt the ſurface of the fleſh was gelatinous as uſual, but in the laſt this appearance was ſcarce perceptible. Theſe experiments confirm the utility, I ſhould rather ſay, the neceſſity of heat to digeſtion in many animals.

CCXXXI. To conclude this curious enquiry, I reſolved to ſee what change would take place upon fleſh when the ſtomach was taken out of the body. I made this experiment upon a cat, a raven, and an owl. Having fed them ſparingly, I cut out the ſtomach, and threw ligatures round the cardia and pylorus to prevent the contents from getting out. They were expoſed to the ſun in a veſſel of water, leſt the heat ſhould dry them. In five hours and an half they were opened: the water had tranſuded through the coats; the ſurface of the fleſh was a little gelatinous, eſpecially in the ſtomach of the raven and owl; but the ſolution was trifling, in compariſon with that which took place when the ſtomach was left in the body. This was what might be expected, when the œſo-

phagus no longer poured its liquor into the ſtomach.

In theſe experiments I did not perceive any eroſion of the ſtomach, any more than in thoſe made with the view of verifying Mr. Hunter's (CCXXIV). I only ſaw what I had ſeen before (ibid), a ſlight excoriation of the inferior part. We muſt therefore infer, that the coats of the ſtomach ſuffer leſs after death than fleſh introduced into it. I gave an hungry dog ſome pieces cut out of the ſtomach of another dog; he eat and it killed him immediately. After the body had lain in a warm ſituation nine hours, the ſtomach was opened. The pieces were ſenſibly diſſolved, but no change was produced upon the ſtomach of the animal, if we except the large curvature, which was ſo much macerated, that the villous coat might eaſily be rubbed off. It is, I think, not difficult to aſſign the reaſon, why the ſtomachs of dead animals are not liable, like their contents, to be diſſolved. Theſe bodies are inveſted on all ſides by the gaſtric fluid, whereas it acts only on the internal ſurface of the ſtomach.

Upon reviewing the experiments related in the CCXXVth and following paragraphs it cannot, I think, be doubted, that digeſtion goes

goes on for ſome time after death. I therefore entirely agree ſo far with the celebrated English anatomiſt, but I cannot with him ſuppoſe, that this function is independent of heat (CCXXIII); numberleſs facts related in this work fully prove the contrary.

DISSERTATION VI.

WHETHER THE FOOD FERMENTS IN THE STOMACH.

CCXXXII. I WILL now, agreeably to my promiſe in the foregoing diſſertation (CCXXI), enquire whether the food ferments in the ſtomach. This opinion was almoſt univerſally adopted by phyſicians about the middle of the laſt century, an æra at which the explanation of the various functions of the human body was ſought in fermentations of various kinds, as it had before been in a ſubtile matter, as it has ſince been in electricity, and is at preſent in divers ſorts of elaſtic fluids. This notion was afterwards combated among others by Boerhaave, who found, by direct obſervations, that this multiplicity of fermentations did not

not exist in nature, but was merely the suggestion of fancy. Of the numberless modifications of this process, which physiologists had imagined, he admitted only that very limited and imperfect one, which, according to him, takes place in the stomach. The food in the stomach of animals, and particularly of Man, is, in his opinion, in circumstances highly favourable to fermentation. The saliva and the gastric fluid serve instead of water; the free access of air, the closeness and heat of the stomach, the nature of the food itself necessarily produce fermentation, as is farther evident from the eructations consequent upon taking food, and the rumbling noise frequently heard in the belly. But the short continuance of the food in that viscus, and other causes, prevent the process from being ever carried to its utmost pitch.

CCXXXIII. Thus far only, according to Boerhaave and his followers, does the fermentation of the food proceed in the stomach. This limitation has been thought too great by Dr. Pringle and Dr. Macbride, two celebrated modern physicians. They find no difficulty in supposing, that a complete fermentation takes place in digestion, and that it is the chief agent in this important

tant function. In their researches on this subject, they have endeavoured to imitate the operations of nature out of the body. They took various animal and vegetable substances, such as are used every day for food; they placed them both by themselves, and mixed with several other substances in a warm temperature, adding a quantity of water or saliva. Under these circumstances they found, that they sooner or later began to ferment; that this process afterwards ran very high, then abated, and at last ended in the decomposition of the several substances, which acquired also a sweet taste. These different gradations of fermentation were evident from the swelling, rarefaction, and intestine movement of the mass, from the generation of a multitude of air-bubbles, and from the substances which at first sunk to the bottom, at length floating on the surface of the fluid. These experiments first made by Pringle, and afterwards repeated and varied by Macbride, determined them both to consider digestion as a process merely fermentative. Their theory is as follows. The food divided by mastication and penetrated by the saliva, begins as soon as it gets into the stomach to be agitated by that intestine movement which always accompanies fermentation; this movement

is excited by the warmth of the place, by the remains of food taken before, by the gastric fluid, and above all by the saliva, which is particularly adapted to produce and promote this process. The first effect of the intestine commotion will be to raise the solid parts of the aliment to the surface of the gastric liquor; here they will be sustained for some time by the air-bubbles; but on their cessation they will fall down again and be thoroughly incorporated with the fluids of the stomach. The peristaltic motion, the alternate pressure of the diaphragm and abdominal muscles, and the continual pulsation of the adjacent large vessels will render this mixture still more complete. In such a state the food passes into the small intestines, where the fermentative motion produces still greater changes in consequence of the mixture of the bile and pancreatic juice. And now the various kinds of food are changed into a sweet, mild, nutritious matter, which ferments briskly, and is denominated *chyle*. In conformity with this theory, these physicians establish a new system of great importance, according to them, in the practice of medicine. It is ingeniously explained by Pringle, in his Appendix containing Experiments on sceptic and antiseptic Substances, and by Macbride

Macbride in his experimental Eſſays on the Fermentation of alimentary Mixtures.

CCXXXIV. The opinion of theſe two modern writers have been adopted by many phyſiologiſts, while others have ſtill adhered to the doctrine of Boerhaave, concerning an incipient and incomplete fermentation only taking place in the ſtomach; ſo that on this ſubject the phyſicians of Europe ſeem to be divided into two ſects. When I read Pringle and Macbride, I had only made a few experiments on the digeſtion of ſome animal and vegetable ſubſtances encloſed in tubes by gallinaceous birds (XXXIX, XL, XLI, XLII, XLIII); and I began to perceive, that the gaſtric juice acted as a menſtruum upon the food. But I could not learn from theſe experiments, whether fermentation takes place at the time they are diſſolved. As indeed the gaſtric fluid is a ſolvent, it may act independently of fermentation; chemiſtry affords numerous inſtances, in which there is no token of fermentation during the diſſolution of the ſolvend. But there is no abſurdity in ſuppoſing, that an inteſtine fermentative motion is generated in the mixture, at the time the gaſtric fluid diſſolves the aliment. And in this caſe, fermentation would accompany digeſtion, though it would not according

to

to the doctrine of Pringle and Macbride (CCXXXIII), be the efficient cause. In order to obtain information concerning this phænomenon which I had not noticed, I had recourse to further experiments. As the theory in question is entirely founded on the fermentation of animal and vegetable matters in vessels, I set in glass phials bread, flesh, and saliva; bread, flesh, and water; flour, saliva, and flesh; for in these mixtures the writers above-mentioned observed the most rapid fermentation. The phials were stopped, and set in a place where the heat amounted to 20°---24° (*a*). The mixtures began, some sooner and others later, to emit air-bubbles, which soon encreased in frequency and size; the surface of the liquor was covered with froth, which continued as long as any air was generated. During this time the mass swelled greatly, the intestine commotion was manifest, and the substances immersed being made specifically lighter by the air-bubbles that adhered to them and the increase of bulk, rose to the surface of the fluid. Here then the tokens of fermentation were apparent, and so far I entirely agree with Pringle and Macbride.

(*a*) Seventy-seven and eighty-six deg. of Fahr. Ther.

CCXXXV. But

CCXXXV. But found logic forbade me to allow so readily, that the same process takes place in the stomach. I had indeed many reasons for with-holding my assent. Not to mention the short continuance of the food in that viscus, a circumstance which did not escape Boerhaave (CCXXXII). I considered, that although the saliva produces and promotes fermentation, the gastric fluid may not have this property. Though the gastric fluid consists in part of saliva, yet as there are several other ingredients, a compound must be formed with properties different from those of its constituent parts. I have adduced many instances to prove, that the gastric fluid retains in some measure its solvent power out of the body; but the saliva never exhibited any such property. I have already shewn, and shall still more clearly shew in the sequel, that flesh immersed in the gastric fluid is not liable to putrefaction; but when put into saliva, it putrefies sooner than in water. This was one of my motives for not immediately adopting the ideas of Pringle and Macbride. It were to be wished, that these physicians had made trial of the gastric liquor also, before they concluded, that what they observed in vessels takes place likewise in the stomach; nor can I well conceive, how they both

both came to overlook a circumſtance of ſo great importance. Moreover we know, that reſt is neceſſary to fermentation; but the ſtomach, beſides the motion of the whole body, has a movement peculiar to itſelf. Laſtly, ſhould fermentation once begin, it muſt in all likelihood be ſoon ſtopped by the freſh ſaliva and gaſtric liquor that are running perpetually, and in no ſmall quantity, into the ſtomach. Theſe two laſt objections have been already ſtarted, though nobody, as far as I know, has taken the pains of verifying them by experiment. But as the queſtion could be decided in this way only, I determined to undertake to ſupply the omiſſion.

CCXXXVI. I have already ſpoken of artificial digeſtion in ſeveral paſſages. Experiments of this kind afforded me an excellent opportunity of obſerving, whether the ſolution of fleſh out of the body was accompanied by fermentation, and I never failed in a ſingle inſtance to attend to this circumſtance. I found, that when the veſſels remained at reſt, a few ſmall air-bubbles began to ariſe in the ſpace of a few hours; they afterwards became larger and more frequent, and adhering to the immerſed ſubſtances, cauſed them to riſe to the ſurface of the liquor. This air was either entangled in the mixture, or, ac-

cording

cording to Pringle and Macbride, formed part of it, was extricated, and rendered elaſtic by the heat, or what ſeems more probable, came from both theſe ſources. The mixtures either ſunk again or continued to float, while they were diſſolved by the gaſtric menſtruum; not the ſlighteſt inteſtine motion was ever perceptible, juſt contrary to what happens when ſaliva is employed. If I now and then ſhook the veſſel a few hours after making the infuſion, very few air-bubbles were generated, and the mixture hardly ever roſe to the ſurface, though it was juſt as well diſſolved as when the veſſel remained at perfect reſt. I find in my Journals, that I agitated the veſſels upon fourteen different occaſions without obſerving the ſmalleſt difference in the reſult of the experiment. I could not therefore allow, that fermentation was the efficient cauſe of theſe artificial digeſtions, nor even that it was a concomitant circumſtance, or an effect; and freſh experiments inclined me more and more to reject this opinion. I have already mentioned the great abundance of gaſtric fluid in crows, and the facility with which they digeſt their food, more eſpecially neſtlings (LXIX, LXXXIII). Among the various trials I made with this fluid out of the body, I endeavoured

deavoured to renew it, as it is renewed in the ſtomach. Several glaſs tubes were filled with it to a certain height, and ſuſpended in a vertical poſition; into the upper extremity a ſmall funnel was put; ſome gaſtric fluid was poured into it from time to time, the narrowneſs of the orifice of the funnel allowed it to fall only drop by drop into the tubes. The lower extremity of the tubes was not cloſely ſtopped, that nearly as much might run out below as fell in from above. Matters being thus arranged, I immerſed in the tube fleſh and bread, both by themſelves and mixed together. The ſolution was exceedingly ſpeedy, on account both of the warmth of the atmoſphere, and the conſtant renewal of the gaſtric fluid. Notwithſtanding the tubes remained at perfect reſt, only a few air-bubbles were diſcharged; not the leaſt inteſtine motion could be perceived; the fleſh and bread fell immediately to the bottom, and remained there till they were gradually incorporated with the gaſtric fluid: in ſhort, they were digeſted without a ſingle circumſtance occurring that uſually attends fermentation.

CCXXXVII. If this proceſs does not take place out of the body, it ſeems highly improbable that it ſhould within; however, to be certain

certain of this, it was proper to consult the senses. Is digestion, according to Pringle and Macbride, a fermentative process? Let us then observe it while it is going on, surprize Nature in her operation, and see in what it consists. With this view, I gave four hens that had been kept fasting twelve hours, some wheat, and in five hours opened the gizzard without killing them. This method I practised in the following experiments, being apprehensive lest opening the animal after death might not answer the end I had in view. Both gizzards were full of grains of wheat mostly broken, and mixed with a semifluid farinaceous paste. The orifice of the pylorus and great part of the duodenum was full of the same paste, which had not in this case much fluidity. Upon examining this paste, both with my naked eye and the microscope, I could not perceive any sign of fermentation; the parts were at perfect rest, and entirely free from air-bubbles. I waited three hours longer before I opened the gizzards of the other two ducks, in order to see whether what had not taken place at the beginning of the process, might not have happened when it was further advanced. In this case, the paste was more diluted with gastric liquor, and of the grains of wheat little was left but the

bran;

bran; I obſerved no more inteſtine motion or air-bubbles than before.

CCXXXVIII. My next experiment was made upon three ravens that had not yet quitted the neſt. Two hours after I had fed them with beef, I opened the ſtomach of one of them. The fleſh was half diſſolved, but I could not perceive any ſign of fermentation. I made the ſame obſervation upon the two others, which were opened an hour and three quarters afterwards, notwithſtanding digeſtion was finiſhed; for nothing remained in the ſtomach but a denſe grey fluid, conſiſting of fleſh diſſolved in the gaſtric fluid.

Of animals with membranous ſtomachs I examined an owl, ſeveral dogs, cats, and land and water-ſnakes, endeavouring always to make my obſervations at three diſtinct times, at the beginning, towards the middle, and at the end of digeſtion. But at no time did I perceive any tendency to fermentation. In one dog and one cat only did I obſerve a few air-bubbles among the food after it was completely digeſted; but there was not the leaſt inteſtine motion perceptible. Serpents, which are animals ſo ſlow of digeſtion, were well adapted to ſhew the progreſs of this function; but neither did they form an exception to the general obſervation. Theſe

facts obliged me to reject the opinion of the British physicians and their followers; nor do I know whether that of Boerhaave is admissible, who, while he excludes a complete, infers an incipient fermentation from the eructations that arise after taking food (CCXXXII); but this may be occasioned by the rarefaction of the air entangled among the aliment, by the mere heat of the stomach.

CCXXXIX. Modern chemists have distinguished three species or degrees of fermentation, the vinous or the sweet, the acetous, and the putrid. As they essentially consist in an intestine motion excited by heat and a proper degree of moisture (*a*), and as no such motion can be seen in the food in the stomach, it follows, that not even the vinous, much less the acetous or putrid takes place in digestion. It remains to be enquired, whether this function is connected with a principle of acidity, as some suppose, or of putrefaction, according to others. I shall state the facts which appear to favour each of these opinions. In behalf of the first, its advocates adduce acid eructations and vomitings from the human stomach, that disagreeable

(*a*) Macquer Dict. Art. *Fermentation.*

acid

acid ſmell which is exhaled from the ſtomachs of granivorous birds and ruminating animals, the acetous taſte of the internal coat; the diminution of the bulk of the contents of the ſtomach of man and animals, not to mention other arguments that may be ſeen in modern phyſiologiſts, and eſpecially in Haller.

CCXL. The prodigious number of ſtomachs I have opened, have afforded me opportunities of acquiring full information on this point. In animals ſtrictly carnivorous, ſuch as birds of prey and ſerpents, the food never has an acetous taſte, either to the taſte or ſmell during the time of digeſtion. The ſame obſervation will apply to frogs and fiſhes; and it may be extended to omnivorous animals, ſuch as crows, when they feed upon fleſh; but the pultaceous maſs reſulting from vegetables, and in particular from bread, now and then acquire a ſlight acidity. I have obſerved the ſame taſte in two dogs, and more frequently in herbivorous animals, ſuch as ſheep and oxen; and alſo in thoſe which are at once herbivorous and granivorous, viz. in the gallinaceous kind; and in the laſt-mentioned claſs, not only the food in the ſtomach had an acetous taſte, but that in the craw likewiſe. In the third diſſertation will be found ſome inſtances of this (CXXXIX,

CXL, CXLI, CXLIII). With respect to Man, I will relate what has happened to myself. During the whole month of May and great part of June, I eat strawberries with sugar and white wine at dinner and supper. From this agreeable mixture I never experience any inconvenience in the day-time; but by what I eat in the evening my sleep is frequently disturbed; the contents of my stomach rise almost into my mouth, and then fall back again, leaving a most disagreeable sour taste behind. This unpleasant circumstance does not, however, prevent me from recovering my rest, and digesting my food perfectly. I have besides many times been subject to a like disagreeable sensation, after eating too much fruit in summer and autumn. Every man must some time or other have been sensible of his meat and drink having turned sour.

CCXLI. I was further desirous of knowing, whether the acid principle sometimes found in the stomach, is capable of dissolving calcareous earth, and such other bodies as acids act upon. I accordingly gave some carnivorous birds pieces of coral and sea-shells, and they were thrown up without any change of colour, or diminution of weight. This was what might be expected. I next made the

the ſame experiment on a hen and a turkey, which were killed in two days. The coral and ſhells were very much corroded, and the former was reduced to pieces; but a moment's reflection ſhewed me, that the corroſion might be owing to the action of the ſtomach, and not to an acid. The doubt, however, might eaſily be removed, by encloſing the ſame ſubſtances in ſtrong metallic tubes. The reſult of ſeveral experiments made in this manner was, firſt, that the pieces of coral and ſhell were almoſt always diminiſhed; but the diminution ſcarce ever exceeded three or four grains: ſecondly, that the ſurface was ſoftened; and thirdly, that it was turned black, eſpecially in the coral. I immerſed at the ſame time the ſame ſubſtances in diluted vinegar, and as ſimilar effects were produced, and particularly the black colour, I inferred, that the phænomena roſe from a like cauſe; laſtly, I repeated the experiment on myſelf. The tubes were covered as before (CCVIII), to prevent any feculent matter from getting into them. They were all voided without inconvenience. When I eat fleſh, with the addition only of a little bread, the ſubſtances were neither diminiſhed nor altered in their colour. But upon eating a large quantity of different vegetables, the coral and

and ſhells were generally diminiſhed and darkened. Theſe facts prove the preſence of an acid principle in the ſtomachs of ſome animals, and Man himſelf. It is, however, not perpetual, but depends on the quality of the food.

CCXLII. This acid ſoon diſappears. I gave ſeveral gallinaceous fowls ſome bread at the ſame time. The ſtomachs were examined at different intervals, viz. two, three, three and an half, four, and five hours afterwards. As long as the bread preſerved its conſiſtence, it was frequently acid; but as ſoon as it was reduced to chyme this taſte was totally loſt. Nor could I perceive the leaſt ſign of it in that which had paſſed into the duodenum. I made upon myſelf the following obſervation.

When the unpleaſant acid taſte mentioned above (CCXL) came into my mouth in conſequence of eating ſtrawberries, I kept myſelf awake twice during the remainder of the night. Acid eructations continued to ariſe for ſome time; they at laſt ceaſed; yet from a ſenſe of weight I knew, that the contents of the ſtomach were not entirely digeſted; but the flatulence that came from them had no longer the ſlighteſt acidity.

CCXLIII. But

CCXLIII. But what produces this acidity in the ſtomach? Does it come from the gaſtric fluid, or from the food? There are good grounds for rejecting the former, and admitting the latter of theſe ſources. In the firſt place, this acidity does not appear on all occaſions; I never could obſerve it ariſing from fleſh. Now if it came from the gaſtric fluid, why ſhould it not be communicated to every kind of food, ſince every kind is alike impregnated with it? Secondly, when I eat vegetables, the effects of an acid in my ſtomach were apparent, but not when I eat fleſh (CCXLI). Thirdly, when vegetable food is completely diſſolved by the gaſtric fluid, it then loſes all acidity (CCXLII). Laſtly, if acid bread be encloſed in tubes and given to a crow, when it is thrown up four or five hours afterwards, the little that remains inſtead of being ſour, is now turned ſweet.

CCXLIV. Notwithſtanding theſe proofs, that this acidity is not owing to the gaſtric fluid, but to the tendency the food itſelf has to turn ſour whenever it is in a warm temperature, is it not ſuppoſed, that this fluid both in Man and animals is of an acid nature? Have not moſt of the antient and many modern phyſicians ſubſcribed to this opinion? I ſhould therefore have incurred the reproach

of negligence, if I had not undertaken a chemical analyſis of it. The gaſtric fluid of every animal mentioned in theſe diſſertations, not excepting my own, was ſubmitted to the following experiments. Having taken the precautions above deſcribed (LXXXI, CCXV), to procure it in a ſtate of purity, I dropped it upon ſalt of tartar *per deliquium*, and into the nitrous and marine acids, without ever perceiving any change of colour, any motion or efferveſcence; whence I was obliged to infer, that the gaſtric fluid is neither acid nor alkaline, but neutral. I thought it would alſo be proper to ſubject thoſe kinds which could be procured in large quantity, as that of the crow, to the action of fire; I therefore entreated my illuſtrious colleague and friend, Counſellor Scopoli, to undertake the analyſis, as he was not only provided with the proper apparatus, but eminent for his ſkill in chemiſtry, of which ſcience he is deſervedly public profeſſor. He complied with my requeſt, and in a few days favoured me with the following account.

Chemical

Chemical Analysis of the Gastric Fluid of the Crow.

"The liquor is turbid, and of a darkish colour. When shaken it emits a smell rather disagreeable.

When triturated with quick-lime or salt of tartar, a fetid urinous odour is exhaled.

It does not effervesce with either of the mineral acids. It gives rather a green hue to syrup of violets.

Two drachms exposed to a gentle heat left a dark-coloured sediment weighing two grains; which attracted the humidity of the air. This residuum had a nauseous smell. It did not effervesce with acids.

I next filtered and distilled it. A darkish matter was left upon the filter, which, when it was dried, appeared in the form of a nut-brown powder, of a salt and bitter taste.

The liquor which passed into the receiver was divided into five portions. The first had a slight taste, and an empyreumatic smell. The second had a stronger taste and smell. The third, fourth, and fifth resembled the second, but the last had the strongest empyreuma.

The

The belly of the retort was almoſt entirely covered with a white ſaline ſubſtance, which upon being triturated with quick-lime emitted a fetid urinous ſmell. In the bottom there remained a tough dark-coloured ſubſtance, reſembling an extract. It did not efferveſce with acids; its ſmell was empyreumatic, and its taſte ſalt, bitter, and nauſeous, This ſalt is neither acid nor alkaline, for it does not efferveſce either with acid or alkalies; but when a little oil of tartar *per deliquium* is mixed with it, it emits a penetrating urinous odour, exactly like that of ſal ammoniac.

From theſe experiments we may conclude, that the gaſtric fluid contains, firſt, pure water; ſecondly, a ſaponaceous and gelatinous animal ſubſtance; thirdly, ſal ammoniac; fourthly, an earthy matter like that which exiſts in all animal fluids.

The ſaponaceous ſubſtance altered by fire emits that unpleaſant empyreumatic ſmell.

The ſal ammoniac being enveloped by the ſoapy matter does not ſublime, as it does when not entangled by other ſubſtances.

The gaſtric fluid of the crow precipitates ſilver from nitrous acid, and forms luna cornea. This phænomenon might induce us to ſuppoſe, that common ſalt exiſts in the gaſtric

tric fluid; but as the ſalt contained in this fluid is not common ſalt but ſal ammoniac, we muſt ſuppoſe, that the ſilver is ſeparated from the nitrous, on account of its ſtronger attraction for the marine acid, which alſo far exceeds the attraction of the volatile alkali for the latter acid.

I wiſh you would repeat theſe obſervations on the gaſtric fluid of animals feeding only on vegetables. If in this alſo ſal ammoniac ſhould be found, we muſt conclude, that the marine acid is generated by the animal powers; and we might ſuſpect, that the marine acid of ſea ſalt is produced by the animals that inhabit the ocean. This is however a mere conjecture.

I am, &c.

SCOPOLI."

A little after I had received this account from my celebrated colleague, I quitted Pavia, to ſpend the ſummer vacation in my own country, where I had no opportunity of making experiments on the gaſtric fluid of any animal ſtrictly herbivorous, though I earneſtly wiſhed for it. I obtained, however, ſatisfactory

factory proofs from the raven, that the ammoniacal ſalt does not depend on animal food, but on the powers of life. I fed five ravens for fifteen days on vegetables alone, and then by means of ſpunges procured a quantity of gaſtric fluid, which I ſuppoſed would have no properties that could be aſcribed to animal food. When I made with it the experiments deſcribed above, it did not appear to be acid or alkaline; it had a ſalt taſte, and upon pouring a few drops into a ſolution of ſilver in the nitrous acid, luna cornea was precipitated. There is therefore every reaſon to ſuppoſe, that if this fluid was diſtilled, ſal ammoniac would be obtained; and therefore, that the marine acid is the product of the animal powers. But whatever we are to think either of this or the other ingenious conjecture of my colleague, which have indeed little connection with our preſent enquiry, it is certain, both from his experiments and my own, that the gaſtric fluid is not either acid or alkaline, but neutral.

CCXLV. But I muſt not conceal thoſe arguments which are adduced to prove, that there is a latent acid in this fluid, though it cannot be detected by any of the ordinary chemical means. It is well known, that a ſmall quantity of acid will curdle milk, an effect

effect produced in the ſtomach of animals, and of ſucking calves in particular, in which caſe we cannot ſuſpect any vegetable acid to be preſent; the phænomenon muſt, therefore, be attributed to the latent acidity of the gaſtric fluid. And as it is continually ſecreted by the internal coat of the ſtomach, we cannot be ſurprized, that this coat in ſome animals ſhould retain the property of curdling milk. This is well known to cooks, who, when they have no rennet, take the innermoſt coat of the ſtomach of a fowl and ſteep it in water; which water, when thus impregnated with the juice of the ſtomach, will ſerve for turning milk as well as rennet itſelf.

Hence ſome have ſuppoſed, that the ſtomachs contains a latent acid. My firſt ſtep was to aſcertain the fact. I therefore triturated the internal coat of a hen with water, which was thus rendered turbid, and in an hour and a half curdled a quantity of milk. The ſame effect was produced by the internal coat of other gallinaceous birds, viz. the capon, turkey, duck, gooſe, pigeon, partridge, quail, treated in the ſame manner. I further diſcovered, that this property belongs alſo to intermediate and membranous ſtomachs, by experiments on that of the crow, heron, birds of prey, the rabbit, the dog, cat, various

reptiles,

reptiles, and ſeveral ſcaly fiſhes. In theſe trials the ſtomachs were freſh. I next tried dried ones, chiefly taken from the gallinaceous claſs, which being almoſt of the conſiſtence of horn, become dry in a very ſhort ſpace, and at the ſame time exceedingly brittle. The reſults were the ſame as before. Nor did it make any difference, though they had been kept ever ſo long. I have had for three years the internal coats of the ſtomach of ſeveral fowls, and upon triturating them with water, while I am writing, they curdle milk as well as at firſt. If they are pounded and mixed with milk, they anſwer the purpoſe equally well.

CCXLVI. But is this property confined to the internal coat? It was eaſy to determine this by treating the others in the ſame manner. The nervous coat has this property in ſome degree, but falls fart ſhort of the internal. Whether cut into ſmall pieces and macerated in water, or mixed immediately with milk, the effect is not ſo ſpeedily produced, nor ſo conſiderable, nor are the curds ſo hard. The muſcular and cellular coats have not this property in the ſmalleſt degree, at leaſt in gallinaceous birds, upon which theſe experiments were made. Hence it would ſeem, that it reſides in the internal coat ſolely; for the

the effects produced by the nervous coat, may be owing to its lying in contact with the former.

CCXLVII. But is this property inherent in the internal coat, or adventitious, and owing to the gastric fluid with which it is impregnated? I incline to the latter opinion, since the gastric fluid so readily curdles milk. I should weary my reader, was I to recount all my experiments. I will therefore only say, that the gastric fluid, from whatever animal it was obtained, possesses this property, whether procured by spunges, by opening the stomach and expressing it out of the glands, and the mouths of the little arteries, with which this viscus in general abounds. I have further found, that the gastric fluid need not be fresh. That of crows, at least, preserves its virtue for three months.

CCXLVIII. But is it a necessary consequence of these experiments, that the gastric fluid contains an acid? As no chemical test shews this quality, there can be no just motive to admit it, unless it can be proved to be a necessary consequence of the curdling of milk. This is maintained by the illustrious Macquer among others, who is of opinion, that whatever bodies of the animal and vegetable kingdom

kingdom coagulate milk, have either a manifest or occult acidity (*a*).

The foundation of this opinion is the common observation, that acids are the sole cause of the curdling of milk. To this reasoning, I shall only oppose a single fact: I have discovered, that though several animal substances are incapable of producing this effect, yet others have this property. Thus for instance, if the blood or bile of a turkey be mixed with milk, it will retain its fluidity; but pieces of the heart, liver, or lungs of that bird, will curdle it readily. This observation is not merely owing to accident; I have made the experiment repeatedly with different turkeys, and always with the same success. If therefore the coagulation of milk be always owing to an acid, we must suppose an acid in the heart, liver, and lungs of the turkey. I am aware, that many chemists, in opposition to the Boerhavian school, think a real acid exists in the different parts of animals, and particularly in the blood; but according to this hypothesis, I cannot comprehend, why the blood of the turkey and other animals does not coagulate milk. With respect to the latent acid of the gastric fluid, I shall

(*a*) Art. Milk.

very

very willingly leave my readers to adopt what opinion they ſhall think moſt probable. The milk I employed for my experiments, was ſometimes that of the ſheep, but generally of the cow. It curdles ſpontaneouſly, as every one knows, ſooner or later, according to the temperature of the atmoſphere. When I mixed it with gaſtric juice, or any other fluid, I always left another portion by itſelf. In the former caſe, the coagulation ſoon took place without any ſign of acidity, whereas milk alone required ſeveral hours, and ſometimes a day or two, and the coagulum had always an acid taſte.

CCXLIX. But it is time to conſider the reaſons adduced by others, to prove that digeſtion is attended with an incipient putrefaction. Theſe reaſons are founded upon facts related by different authors, and detailed in their order by Haller, in his great work (*a*). Nothing, according to them, can be more evident, than the ſigns of putrefaction during digeſtion. The ſtomach of a hyena and of a ſerpent, have been obſerved to emit an intolerable ſtench. The breath of the lion and eagle is very fœtid, as alſo that of the dog, when digeſtion has been prevented by the

(*a*) T. 6.

 exhi-

exhibition of opium. A dog without taking opium, was obſerved to emit an excrementitious odour from his ſtomach; the food in the ſtomach of birds has nearly that ſmell. The ſame obſervation has been applied to fiſhes; and the inſtance of a dog-fiſh has been adduced, of which the ſtomach was full of a fœtid jelly, that contained the food diſſolved. The contents of the human ſtomach ſometimes become fœtid. Vegetable ſubſtances alſo degenerate into a putrid maſs, when they continue long in the ſtomach, as appears from the putrid ſmell they exhale, the green colour they impart to tincture of mallows, and the alcaline principle they afford on diſtillation.

After having related theſe facts, the Swiſs phyſiologiſt proceeds to give his own opinion. He thinks, that in digeſtion there is only an incipient, not a complete putrefaction; which only takes place when the food remains a long time in the ſtomach, as is evident from the facts juſt mentioned. He alſo ſuppoſes, that the change produced by the digeſtive powers, eſpecially in the human ſtomach, approaches nearer to putrefaction than aceſcency; this he infers, from the putrid ſmell that exhales from fleſh found in the ſtomach of ſome animals, notwithſtanding there has been

been no impediment to digestion (*a*). This opinion, adopted before Haller by Boerhaave (*b*), has moreover been received by two celebrated writers, Gardane (*c*), and Macquer (*d*).

CCL. Notwithstanding the respectable authority of these authors, I do not think the facts adduced, sufficient to persuade an impartial philosopher; they are not only too few, but were observed by mere accident; nor had the observers the smallest intention of entering into a full discussion of this point.

Though the time requisite for digestion in different animals is different, yet in many it does not exceed five or six hours, and in some is still shorter. Now it seemed proper to examine what change flesh set to putrify, would undergo in that space of time; I therefore took some fresh veal cut into small pieces, and put it in a phial of water, which was stopped with paper. The phial was put into a stove, where the mercury rose to between 30 and 35°.

About the beginning of the fourth hour, the flesh had lost its red colour, and was

(*a*) L. c.
(*b*) Chem. T. 2.
(*c*) Essai pour servir à l'Histoire de la Putrefaction.
(*d*) Art. common Salt.

turning blue. It was alſo become flabby, but for nine hours it had no putrid ſmell. Mutton and beef, in ſeveral trials, did not anſwer to this time exactly, but no bad ſmell was ever perceptible for eight hours. Theſe experiments ſhew, that fleſh eaten by many animals, among which Man may be enumerated, has not time to run into the putrefactive fermentation, eſpecially as the temperature of animals is lower than that to which theſe ſeveral ſorts of meat were expoſed. However, for greater certainty, I made the following trials. I have before mentioned introducing into the ſtomachs of crows, pyriform glaſs veſſels, of which the ſmall end was open, and came out at the mouth (LXXXIX).

I now took two of them, and putting ſome beef, with a little water, into one, and ſome veal into the other, forced them down the throat of ſome crows. In order to examine the ſtate of the fleſh, I now and then drew them up, and immediately returned them. Between the ninth and tenth hours, the beef emitted an odour, which though it could not be called putrid, was diſagreeable. At the expiration of the tenth hour, there was a diſtinct putrid ſmell that became gradually ſtronger and ſtronger. In a day the fleſh turned livid, acquired a nauſeous taſte, and the

the particles began to ſeparate. The ſame appearances took place rather ſooner in the veal. It therefore appears, that fleſh in the heat of this ſpecies of bird requires a longer time to putrify, than to be digeſted. After the glaſs veſſels were taken out of the ſtomach, I gave one of them the ſame quantity of beef and veal; and upon opening the ſtomach in three hours, found that it was entirely conſumed.

CCLI. Theſe experiments prove, that no putrid tendency is ever acquired by meat during digeſtion. Nor did I ever perceive any ſuch tendency in food lying in the ſtomach (LXV, CCIX); yet as I had never made experiments for this expreſs purpoſe, and as ſome phyſiologiſts adduce facts to prove the contrary (CCXLIX), I was under the neceſſity of examining the ſtomach of various animals, with this ſole view.

Four hens were fed with kid, and in two hours one was killed: the ſtomach was full; the fleſh ſtill retained its natural ſweet ſavour, which at the ſurface was mixed with a bitteriſh taſte, occaſioned by its being impregnated with the gaſtric fluid. It had no ſmell, except that of this fluid. An hour afterwards the ſtomach of another hen was examined; and here the fleſh was beginning to be converted into

a gelatinous paſte, its ſmell was rather diſagreeable; I know not how to deſcribe it, but it was not at all penetrating, or putrid; the colour was ſtill reddiſh, it had not the leaſt nauſeous taſte, nor did it effervеſce with acids, or change the colour of ſyrup of violets. Thus we ſee, it ſhewed no ſign either of incipient, or advanced putrefaction. In another hour the third hen was killed: the ſtomach contained a pultaceous maſs, more fluid than in the former caſe; but there was not the ſmalleſt token of putrefaction, any more than in the fourth hen, which was opened three hours afterwards, when the craw was empty, and the contents of the gizzard were now diſſolved.

CCLII. Some frogs juſt killed were ſet before two herons; the birds being hungry, devoured them greedily. In ſix hours one of them was opened; but whether the toughneſs of the ſkin retarded digeſtion, or whether that proceſs is ſlow in herons, the frogs had not loſt their ſhape; though the heads and limbs were either ſeparated, or on the point of being ſeparated from the trunk, and the fleſh was become very ſoft. The taſte, except the uſual bitterneſs, had nothing nauſeous, and the ſmell was by no means putrid. I waited five hours longer before I killed the ſecond;

ſecond; when I found but little fleſh in the ſtomach, and that little was entirely decompoſed, but did not emit the leaſt putrid ſmell.

If fowls and herons afforded no token of putrefaction, much leſs could I expect it from the birds upon which my next trials were made; I mean, young owls, which digeſt fleſh in three, or at moſt four hours. A young dog and cat were next fed, at the ſame time, with boiled beef. The former was opened in four hours and an half. The ſtomach was full of a maſs of ſoftened fleſh, which emitted a very ſlight ſmell, exactly reſembling the ſmell of the gaſtric fluid. The ſtomach of the cat was opened in five hours and an half, and was found to contain ſome remains of fleſh, or rather a pulpy matter, which as in the former caſe, had the ſmell of gaſtric fluid. The fleſh, when nearly digeſted, did not change the colour of ſyrup of violets, or efferveſce with acids.

CCLIII. There are animals which retain the food in the ſtomach for a much longer time, as the falcon. Of that upon which I made ſo many experiments, I have already obſerved, that it would devour a whole pigeon at once, and continue without food the whole day afterwards (CLX). Whence, as alſo from

its great bulk, we may infer, that the fleſh remains a long time in the body before it is entirely digeſted. Some months after this was killed, another of a different ſpecies fell into my hands; it was of a larger ſize, and had no craw, ſo that the food paſſed immediately into the ſtomach. Notwithſtanding it was pretty tame, and therefore valuable, yet I ſacrificed it for the ſake of theſe experiments, eighteen hours after it had devoured a chicken. What remained in the ſtomach weighed two ounces; it conſiſted of a pulp, in which the fibres could yet be diſcerned; but neither when ſubjected to the before-mentioned chemical trials, or when ſmelled and taſted, did it ſhew any ſign of putrefaction. But among the animals that retain their food for a long time in the ſtomach, thoſe with cold blood, and eſpecially vipers, are, as we have ſeen, the moſt remarkable. A piece of lizard's tail preſerved ſomewhat of its muſcular ſtructure, after having remained five days in the ſtomach of a land-ſnake (CXVIII). Three water ſnakes had not conſumed all their food at the end of three days (CXXI). Another not even in ſix days (CXXV). A lizard remained ſixteen days in the ſtomach of a viper, without loſing its natural form (CXXVII). Other cold animals, ſuch as eels, newts, and frogs, muſt

muſt not be forgotten. Four eels that had eaten fiſh, retained a little after the expiration of three days, eighteen hours (CXXIX). On the fifth day, ſome frogs had not quite digeſted pieces of inteſtine (CVI); which alſo happened to newts, two days after they had been fed with earth-worms (CVIII). But notwithſtanding the food continued ſo long in the ſtomach of theſe ſeveral animals, I have expreſsly noticed, that it had not begun to putrify (CXXVII).

CCLIV. I have met only with two inſtances which though they do not coincide with this invariable conſtancy of nature, by no means detract from the certainty of the conſequences that are to be deduced from it. Among the crows that were obliged to ſwallow tubes for a conſiderable length of time, ſome ſuffered in their healths, and became lean, though they were copiouſly ſupplied with food. But as they did not take it voluntarily, and as it was my wiſh to keep them alive for the ſake of experiments, I forced ſome fleſh down the throats of two, but to no purpoſe; for they both died, one thirteen, the other fifteen hours afterwards. My curioſity led me to open them, and I found that the fleſh continued whole and undigeſted, and moreover that it was become putrid. But this evidently

aroſe

arofe from the morbid condition of the animal, by which the gaftric fluid was altered, and rendered inefficacious. For this fpecies of birds, as I have feen in a hundred inftances, digefts flefh very fpeedily, and without any token of putrefaction appearing. It is alfo probable, that the putrid ftate of the food in the animals mentioned in the CCXLIXth paragraph, arofe from their morbid condition; efpecially as it remained fo long in the ftomach of fome of them. It may alfo happen, that when an animal in health is killed and kept unopened a confiderable time, as often happens, the food in the ftomach may be found in a putrid ftate.

In the fame paragraph, the breath of the lion and eagle are faid to be fœtid. That of the lion I never had an opportunity of examining, but with the eagle it is far otherwife; for when I ftroaked the head gently, it would fometimes open its mouth, and raife a gentle cry; on thefe occafions it neceffarily made a long expiration, and in winter the breath appeared in the form of a little cloud. This cloud I have often fmelled, and caufed others to fmell, both when the bird was fafting, when the ftomach was full, and when the food was recently digefted; but it was never

fœtid,

fœtid, and indeed did not ſeem to have any kind of odour.

CCLV. The experiments deſcribed in the CCL, CCLI, CCLII, and CCLIIId paragraphs, not only ſhew that digeſtion is unaccompanied by putrefaction, but might induce us to ſuppoſe, that the ſtomach is provided with an antiſeptic principle. Fleſh incloſed in the pyriform glaſſes that were introduced into the ſtomach of crows, ſhewed evident ſigns of putrefaction in ten hours; whereas in eighteen they ſhew no appearance of the kind, when it is in immediate contact with the ſtomach (CCLIII). And although ſerpents, and the other amphibious animals above-mentioned (CCLIII) are of a cold temperature, yet in their temperature, which is nearly equal to that of the atmoſphere, fleſh becomes putrid in two days, ſometimes in one, and ſometimes even in a ſhorter time, while in their ſtomachs it remains untainted frequently for a much longer ſpace. I could not therefore but conclude, that there is preſent in theſe caſes, ſome cauſe that prevents the corruption which ſupervenes out of the body. What can this cauſe be? It was not difficult to detect it. I called to mind thoſe unfiniſhed digeſtions, which take place when fleſh is immerſed in gaſtric fluid contained in phials; where it is diſſolved without ever turning

turning putrid, notwithſtanding it is kept long enough, and expoſed to a ſufficient heat. I could not then doubt, that the gaſtric juices are at once the ſolvent, and the preſervative from putrefaction. Further reflection furniſhed me with proofs ſtill more deciſive. It appears from various paſſages in the preceding diſſertations, that in attempts to produce artificial digeſtion, little or no ſolution takes place, unleſs the fluid extracted from the ſtomach is expoſed to a conſiderable heat (CXLII, CLXXXVI, CCI, CCXVII). But without this condition, it retains its antiſeptic powers (CLXXXVI, CCXVII). Two phials, one containing ſome gaſtric fluid from a crow, and the other from a dog, together with ſome veal and mutton, were kept thirty-ſeven days in winter, in an apartment without fire: the fleſh was not either conſumed or turned putrid; while ſome that was immerſed in water, began to emit a fœtid ſmell on the ſeventh, and about the thirtieth day was changed into a very offenſive liquamen. It is proper to add, that the gaſtric fluid at laſt loſes, though kept in phials ever ſo cloſely ſtopped, its antiſeptic quality, but it never becomes putrid itſelf. This at leaſt I found to be the caſe with ſome taken from a crow, and kept two months.

CCLVI. The

CCLVI. The discovery of this antiseptic property led me to enquire what would be the effect of immersing flesh, more or less putrid, in gastric fluid. Four portions that had an insupportable smell, were set in four bottles, which I filled with four different kinds of gastric fluid, viz. of a dog, a crow, an owl, and an eagle. This was done in March, and the bottles were kept twenty-five days in an apartment, where the heat was never less than 8, and never exceeded 12°. I could not perceive that it was at all more dissolved than if it had been immersed in water. With respect to the fœtid smell in the phials containing lamb and veal, it continued unchanged; but in the two others, which contained fowl and pigeon, it seemed rather diminished. This result suggested to me, that the gastric fluid might not only impede putrefaction, but restore putrified substances. I therefore repeated the experiment in June, and found that my suspicion was well founded. Some fowl and pigeon, in which putrefaction was pretty far advanced, were immersed in the gastric fluid of a dog and falcon, and remained in it thirty-seven hours, in which time they were reduced to a jelly, but had nearly lost their offensive smell. On comparing this with the preceding experiment,

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I conjectured, that the ſuperior efficacy of the gaſtric fluid in the latter caſe, proceeded from the warmth of the ſeaſon: and this induced me to expoſe the ſame fleſh under the ſame circumſtances, to the ſun about the middle of June. And now ten hours completely took away the fœtid ſmell. I did not neglect making the ſame experiment with the gaſtric fluid of other animals; the fleſh generally loſt its diſagreeable odour, but ſometimes for a reaſon, which I cannot aſſign, retained it in part. It is proper to add, that the recent fluid was always more efficacious than the old.

CCLVII. If we conſider the CCLV and CCLVIth paragraphs, we muſt conclude, that putrid fleſh loſes this quality in the ſtomach of animals. Before I attempted to aſcertain this point by experiment, nature herſelf gave me a deciſive proof of it. At the time I kept a great number of fowls for my enquiries, I perceived that when they are allowed to eat at will, they cram their craw ſo full, that it is ſixteen or twenty hours before it is completely evacuated. Curioſity led me to kill a cockrel that had about an ounce of meat, which happened to be bruiſed fleſh, remaining in its craw: and I was ſtruck with ſurprize, when I perceived that it had a ſtrong putrid

putrid ſmell; it was become ſoft, had a dull red colour, and a nauſeous taſte: I immediately proceeded to examine the contents of the ſtomach; but here I found the fleſh quite decompoſed with a bitter ſweet taſte, and a ſmell not in the leaſt fœtid. The liquor therefore of the ſtomach, had corrected the putrid quality which the fleſh had acquired in the craw. The ſame thing took place in ſome hens. The fleſh in the craw became putrid in ſixteen hours, while that in the ſtomach had no diſagreeable odour. It ſhould, however, be remarked, that the putrefactive fermentation never runs ſo high within the craw, as it does out of the body, even when the heat is leſs ſtrong. Whence I ſuſpected, that the fluid of the craw might alſo poſſeſs an antiſeptic power, though in a degree very far inferior to that of the ſtomach.

CCLVIII. I took a putrid piece of beef's lights, and dividing it into five portions, faſtened a ſtring to each, and then thruſt them into the ſtomachs of five ravens. The end of the ſtring was brought out at the beak, as on former occaſions (LXVIII), that I might be able to examine the fleſh at pleaſure. In three quarters of an hour, two of the pieces were drawn up: they were waſted, and at firſt ſeemed to have loſt their putrid ſmell, but upon

upon wiping off the gaſtric fluid, it became again ſenſible, but it was much diminiſhed. Half an hour afterwards another piece, upon examination, was found to be ſtill more waſted, and to have loſt almoſt all its bad odour, even when the gaſtric fluid was carefully wiped away. In an hour afterwards the two remaining pieces were drawn up. They were reduced to the ſize of a pea, and it would have been impoſſible to tell that they had been ever putrid, ſo perfectly were they recovered; even the taſte had nothing diſagreeable, except the bitterneſs which is always preſent on ſuch occaſions.

The great length of the neck prevented me from repeating this experiment upon the heron. I forced a ſemi-putrid frog, from which the ſkin had been taken, into the ſtomach, but I could not draw it up again; it was therefore neceſſary to cut the ſtring at the beak, when the bird immediately ſwallowed it. It was my intention to kill the heron in about an hour, that I might examine what change the frog had undergone. But it was vomited before that time, probably on account of its being a diſguſting food; for however greedily the heron devours living fiſhes and frogs, it abſtains from them when they are turning putrid. The gaſtric fluid

fluid had, notwithſtanding, exerted both its antiſeptic and ſolvent powers, during the forty-three minutes the frog had been in the ſtomach. Some tin tubes were then filled with putrid fiſh, and given to the animal; they were not, as before, thrown up, perhaps, becauſe the putrid matter was not in contact with the ſtomach. The bird was killed three hours afterwards; what remained in the tubes weighed one-ſeventh of an ounce; it reſembled a thick gelatinous paſte, in which a few fleſhy fibres might yet be diſtinguiſhed, and which retained no veſtige of its former putrid ſtate.

CCLIX. I treated ſeveral ſmall birds of prey, ſuch as the two ſpecies of owl above deſcribed, and a young hawk, as I had done crows (CLVIII). They were fed with inteſtine, liver, and lungs of ſheep, more or leſs putrid. Solution took place, and the putrefaction was corrected according to the time of the continuance of the fleſh in the ſtomach. The hawk twice threw up what it had ſwallowed, probably, becauſe its putrid ſtate made it diſagree with the ſtomach, for this never happened when it was fed with freſh meat. The gaſtric juices of the eagle produced the ſame effect upon fleſh incloſed in tubes, and introduced into its ſtomach. Animals of cold

blood having very ſlow digeſtive powers, were long in correcting the putrefaction of fleſh. This effect, however, was at laſt produced. The only precaution neceſſary, was to return the ſubſtances into the ſtomach when they were vomited, which often happened.

The laſt experiments I made with this view, were upon a cat, a dog, and myſelf. I was obliged to force the putrid fleſh down the throat of theſe animals, for notwithſtanding they were exceedingly hungry, they obſtinately refuſed it. The dog retained what was forced upon him, but the cat vomited it along with a quantity of foam, and a liquor that appeared to be gaſtric fluid. The fleſh, which when it was given was exceedingly fœtid, had now loſt its ſmell entirely; of this, another cat, by eating it without afterwards throwing it up, gave me a clear proof. Upon opening the ſtomach, I found the fleſh half digeſted, and with no other ſmell than that which freſh meat uſually emits in like circumſtances. In two hours and a half the dog was opened. The fleſh lay in a little lake of gaſtric fluid, nearly decompoſed, nor did it either in taſte or ſmell reſemble tainted meat. The experiment I made on myſelf, conſiſted in ſwallowing, at five different times, five tubes covered with linen, like thoſe mentioned

tioned in the CCVIIIth paragraph: they were full of different ſorts of putrid fleſh. I voided them ſeparately, and in each there was ſome of the contents remaining, but not one exhibited the ſmalleſt token of putrefaction. Hence then it appears, that the various claſſes of animals, and Man among the reſt, in an healthy ſtate, are endowed with the power, not only of checking the putrefaction of ſubſtances lodged in the ſtomach, but alſo of correcting them when already putrid.

CCLX. By this diſcovery I was led to reflect, that many animals living upon fleſh, and matters that have a tendency to run into the putrefactive fermentation, never feed but upon ſuch as are freſh and ſweet; and that, if by any accident putrid food ſhould get into the ſtomach, they are ſubject to vomiting and various bad ſymptoms, and even death itſelf: ſome inſtances of vomiting excited by this cauſe, may be ſeen above (CCLVIII, CCLIX); while on the other hand, many animals delight in corrupted ſubſtances, as for inſtance, the multitude of loathſome inſects and worms that reſide in ſewers and ſepulchres, and feed upon decaying carcaſes. Among birds and quadrupeds, there are alſo ſome that ſeek tainted fleſh; ſuch as the crow, the kite, the vulture, among the former; and among the

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latter, the chacal and the hyena. While other animals fly the miaſmata that ariſe from bodies in ſuch a ſtate, theſe ſeek and are guided by them to their abominable repaſts. But now we are acquainted with the antiſeptic virtue of the gaſtric fluid, the diſguſting manners of theſe animals ought no longer to ſurprize us, for the food, however putrid, muſt be totally changed before it is converted into nutriment and animalized. And although the putrid quality is corrected by other animals, yet food in that ſtate is noxious to them, on account of the diſagreeable impreſſion it makes on the organs of ſmell and taſte, as alſo upon the ſtomach, by which, and particularly by their noiſome miaſmata, the nervous ſyſtem is probably irritated. It beſides ſeems likely, that the antiſeptic power of the gaſtric fluid of the former, is greater and more efficacious, and conſequently that it more readily and more completely corrects putrefaction. Habit, which is juſtly reputed a ſecond nature, may bring animals, that naturally abominate putrid food, to live very well upon it. We have already ſeen the converſion of a pigeon from a granivorous into a carnivorous animal (CLXXV); and I brought it to eat not only freſh fleſh, but ſuch as was fœtid, and even completely putrified. The bird at firſt ab-
ſolutely

ſolutely refuſed it, and I was obliged to force it into the ſtomach; for ſome days it ſuffered from this treatment, and became evidently leaner. But by degrees nature became inured to the food, and the pigeon, ſtimulated by hunger, took it ſpontaneouſly, till at laſt it recovered its plumpneſs; and now its appetite for tainted, was as keen as it had been before for ſweet meat. We may learn from this inſtance, that cuſtom is capable of changing diſagreeable, and even noxious food, into good nouriſhment.

CCLXI. But what ſhall we ſuppoſe enables the gaſtric fluid to check and correct putrefaction? As it contains a ſalt, and that of the ammonical kind (CCXLVI), and as beſides the experiments of Pringle ſhew, that all ſalts, whether acid, alkaline, or neutral, whether volatile or fixed, are antiſeptic (*a*), it is obvious to conjecture, that theſe two qualities ariſe from the ſame ſource. I conceived, however, before I determined abſolutely, that it would be proper to attempt a few experiments. It is obſerved by Pringle, that we muſt employ common ſalt, which ſo nearly reſembles ſal ammoniac, in conſiderable quantity, if we wiſh it to act as an antiſeptic; other-

(*a*) Appendix, containing experiments on ſeptic and antiſeptic ſubſtances.

 wiſe,

wiſe, it is ſo far from checking, that it promotes putrefaction. Thus a drachm of ſalt, diſſolved in two ounces of water, keeps meat ſweet but a little while, and twenty-five grains a ſtill leſs time; while ten, fifteen, and even twenty grains haſten its corruption. This paradox has been confirmed in France by the learned Mr. Gardane. Notwithſtanding theſe authorities, I determined to bring the matter to the teſt of experiment. I therefore took four phials, and putting into each three pennyweights, ſix grains of freſh beef, pounded very ſmall, I poured upon it an ounce and half of water. In the firſt phial were diſſolved ten grains of common ſalt, in the ſecond fifteen, in the third twenty, and the fourth was left without ſalt, as a term of compariſon. The temperature of the place where they were kept, was about fifteen degrees. The firſt phial began firſt to emit a fœtid ſmell, the fourth next, then the ſecond, and laſtly the third. The other tokens of putrefaction appeared in the ſame order. When ſal ammoniac was ſubſtituted in the place of common ſalt, the only difference in the reſult, conſiſted in the phial which contained no ſalt, and that which contained ten grains, beginning to exhale a putrid ſmell at the ſame time. It appears, therefore, that Pringle's experiment

periment was accurate, and that the ſame thing nearly is true of ſal ammoniac. In order to determine whether the antiſeptic property of the gaſtric fluid ariſes from the ſal ammoniac it contains, I diſſolved a quantity of that ſalt by degrees in water, till it had nearly acquired the ſame ſaltneſs as the gaſtric fluid; ſome bruiſed fleſh was then immerſed in it. That the water and the liquor of the ſtomach had nearly the ſame ſaltneſs, I aſſured myſelf, both by taſting it, and by dropping a few drops of each into a ſolution of ſilver in the nitrous acid, when each afforded the ſame white precipitate. But it is this cauſe that prevents putrefaction; for the fleſh immerſed in the ſalt water, emitted a fœtid odour ſooner than other fleſh of the ſame kind, infuſed in common water: and although when more ſal ammoniac was employed, putrefaction was retarded, it was not prevented; to attain this end, eighteen or twenty times as much ſalt as is contained in the gaſtric fluid was requiſite. Theſe facts ſeem clearly to ſhew, that the antiſeptic quality of the gaſtric fluid does not depend on the ſmall quantity of ſal ammoniac it contains.

CCLXII. From the ſceptic power of common ſalt in ſmall quantity, Mr. Gardane deduces a conſequence, which it may be pro-

per to notice in paſſing. He thinks the common ſalt we take with our food, being always in little doſes, forwards digeſtion, by promoting putrefaction; upon which, according to him, as we have ſeen above (CCXLIX), that function depends. Though my numerous experiments completely deſtroy this ſuppoſition, yet it ſeemed worth while to try what would happen to fleſh ſeaſoned with ſuch a proportion of common ſalt as haſtens putrefaction, and given to different animals. Some tubes, filled with fleſh thus prepared, and others, with ſome of the ſame kind, without ſalt, were given to a dog and a cat. The animals were opened in five hours, and upon examining the tubes, I could not perceive that the ſalt had occaſioned any difference. What remained undiſſolved, had ſtill a ſlight ſalt taſte, but not the leaſt diſagreeable ſmell; and it was juſt as much waſted as the other. It therefore appears, that this ſmall doſe of ſalt had neither promoted digeſtion, nor produced any tendency to putrefaction, being overpowered by the antiſeptic quality of the gaſtric fluid.

CCLXIII. But to return from this digreſſion. If the ſalt contained in the gaſtric fluid is not the cauſe of its antiſeptic power, to what other principle can it be owing? Macbride's

bride's theory concerning the origin of this property in ſo many bodies, has great ingenuity. The coheſion and ſolidity of ſubſtances, is in his opinion owing to the fixed air they contain. Now when by any means this is taken away, the mutual adheſion of the ſeveral parts will be deſtroyed, and the body will either run into the putrefactive fermentation, or crumble into duſt, according to the nature of its conſtituent parts. Hence it neceſſarily follows, that whatever ſubſtance has the power of impeding the ſeparation of fixed air, or reſtoring it when ſeparated, will alſo prevent or correct putrefaction. But antiſeptic matters have, according to this phyſician, ſuch a power. A piece of fleſh, for inſtance, ſurrounded by a ſubſtance of this kind, is kept ſweet, becauſe the fixed air cannot make its eſcape; and that, probably, on account of its pores being blocked up by the finer particles of the antiſeptic matter. Hence the fleſh will long preſerve its natural taſte and conſiſtence. If it has already become putrid, it will receive fixed air from the antiſeptic body, and hence ceaſe by degrees to exhale a fœtid ſmell, loſe its fluidity and flabbineſs, and at laſt recover its ſweetneſs and firmneſs (*a*).

(*a*) Macbride, l. c.

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Will not this theory account for the antiseptic power of the gaſtric fluid? Without going out of my way to examine the foundation on which it reſts, I will obſerve, that it ſeems by no means to afford the information wanted, ſince the gaſtric fluid is an antiſeptic of a ſingular ſort. Other ſubſtances poſſeſſing this property, while they keep away putrefaction, preſerve or reſtore the coheſion of the parts; whereas the gaſtric fluid being at once an antiſeptic and ſolvent, while it prevents or corrects putrefaction, reduces bodies into very ſmall particles. We muſt therefore conclude, that the property of this animal fluid ariſes from ſome other principle, though I cannot determine what that principle is, both for want of experimental data, and on account of the imperfect ſtate in which phyſicians have left the theory of putrefaction. I therefore choſe to acknowledge my ignorance, rather than invent ſome gratuitous hypotheſis; ſuch a mode of proceeding would ill agree with the diſpoſition of one, who has no other object in view than the diſcovery of truth.

CCLXIV. For the ſake of my readers, it may be proper to recapitulate what has been proved in this diſſertation. Firſt, of the three ſpecies of fermentation eſtabliſhed by modern chemiſts

chemiſts and naturaliſts, viz. the ſweet, the acetous, and the putrid, neither takes place in digeſtion. Secondly, Though an acid ſometimes appears during this proceſs, yet it diſappears entirely towards the concluſion of it. Thirdly, Putrefaction never in health attends digeſtion. Fourthly, The gaſtric fluid is a real antiſeptic. I ſuppoſe my proofs, however concluſive, will not avail with thoſe who eſtabliſh it as an axiom, that wherever there is heat and moiſture, there muſt be fermentation; and think that it muſt therefore neceſſarily take place in the food, and not only in the ſtomach and inteſtines, but in the chyliferous and ſanguiferous veſſels: they indeed limit their doctrine ſo far as to ſay, that whereas out of the body it goes on rapidly, and with an inteſtine commotion, in the body of it is ſlow, weak, and generally imperceptible. Let me intreat theſe learned and zealous advocates for fermentation to reflect, that my experiments are not directly repugnant to theirs. I only pretend to ſhew, that not the ſmalleſt ſenſible fermentation takes place in the ſtomach of animals or Man. With reſpect to ſenſible fermentation, as it is amongſt uncertain things, ſound logic forbids me alike either to admit or reject it.

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APPENDIX.

ON THE DIGESTION OF THE STOMACH AFTER DEATH.

By JOHN HUNTER, F.R.S. and Surgeon to St. GEORGE's Hospital*.

AN accurate knowledge of the appearances in animal bodies that die of a violent death, that is, in perfect health, or in a sound state, ought to be considered as a necessary foundation for judging of the state of the body in those that are diseased.

But as an animal body undergoes changes after death, or when dead, it has never been sufficiently considered what those changes are; and till this be done, it is impossible we should

* See Philosophical Transactions, Vol. LXII. p. 447.

ſhould judge accurately of the appearances in dead bodies. The diſeaſes which the living body undergoes (mortification excepted) are always connected with the living principle, and are not in the leaſt ſimilar to what may be called diſeaſes or changes in the dead body: without this knowledge, our judgment of the appearances in dead bodies muſt often be very imperfect, or very erroneous; we may ſee appearances which are natural, and may ſuppoſe them to have ariſen from diſeaſe; we may ſee diſeaſed parts, and ſuppoſe them in a natural ſtate; and we may ſuppoſe a circumſtance to have exiſted before death, which was really a conſequence of it; or we may imagine it to be a natural change after death, when it was truly a diſeaſe of the living body. It is eaſy to ſee therefore, how a man in this ſtate of ignorance muſt blunder, when he comes to connect the appearances in a dead body with the ſymptoms that were obſerved in life; and indeed, all the uſefulneſs of opening dead bodies depends upon the judgment and ſagacity with which this ſort of compariſon is made.

There is a caſe of a mixed nature, which cannot be reckoned a proceſs of the living body, nor of the dead; it participates of both

both, inaſmuch as its cauſe ariſes from the living, yet cannot take effect till after death.

This ſhall be the object of the preſent paper; and, to render the ſubject more intelligible, it will be neceſſary to give ſome general ideas concerning the cauſe and effects.

An animal ſubſtance when joined with the living principle, cannot undergo any change in its properties but as an animal; this principle always acting and preſerving the ſubſtance, which it inhabits, from diſſolution, and from being changed according to the natural changes, which other ſubſtances, applied to it, undergo.

There are a great many powers in nature, which the living principle does not enable the animal matter, with which is is combined, to reſiſt, viz. the mechanical and moſt of the ſtronger chemical ſolvents. It renders it however capable of reſiſting the powers of fermentation, digeſtion, and perhaps ſeveral others, which are well known to act on this ſame matter, when deprived of the living principle, and entirely to decompoſe it. The number of powers, which thus act differently on the living and dead animal ſubſtance, is not aſcertained: we ſhall take notice of two, which can only affect this ſubſtance when deprived of the living principle; which are, putre-

putrefaction and digestion. Putrefaction is an effect which arises spontaneously; digestion is an effect of another principle acting upon it, and shall here be considered a little more particularly.

Animals, or parts of animals, possessed of the living principle, when taken into the stomach, are not the least affected by the powers of that viscus, so long as the animal principle remains; hence it is that we find animals of various kinds living in the stomach, or even hatched and bred there: but the moment that any of those lose the living principle, they become subject to the digestive powers of the stomach. If it were possible for a man's hand, for example, to be introduced into the stomach of a living animal, and kept there for some considerable time, it would be found, that the dissolvent powers of the stomach could have no effect upon it; but if the same hand were separated from the body, and introduced into the same stomach, we should then find that the stomach would immediately act upon it.

Indeed, if this were not the case, we should find that the stomach itself ought to have been made of indigestible materials; for, if the living principle was not capable of preserving animal substances from undergoing

ing that proceſs, the ſtomach itſelf would be digeſted.

But we find on the contrary, that the ſtomach, which at one inſtant, that is, while poſſeſſed of the living principle, was capable of reſiſting the digeſtive powers which it contained, the next moment, viz. when deprived of the living principle, is itſelf capable of being digeſted, either by the digeſtive powers of other ſtomachs, or by the remains of that power which it had of digeſting other things.

From theſe obſervations, we are led to account for an appearance which we often find in the ſtomachs of dead bodies; and at the ſame time they throw a conſiderable light upon the nature of digeſtion. The appearance which has been hinted at, is a diſſolution of the ſtomach at its greateſt extremity; in conſequence of which, there is frequently a conſiderable aperture made in that viſcus. The edges of this opening appear to be half diſſolved, very much like that kind of diſſolution which fleſhy parts undergo when half digeſted in a living ſtomach, or when diſſolved by a cauſtic alkali, viz. pulpy, tender, and ragged.

In theſe caſes, the contents of the ſtomach are generally found looſe in the cavity of the abdomen, about the ſpleen and diaphragm.

In many ſubjects this digeſtive power extends much further than through the ſtomach. I have often found, that after it had diſſolved the ſtomach at the uſual place, the contents of the ſtomach had come into contact with the ſpleen and diaphragm, had partly diſſolved the adjacent ſide of the ſpleen, and had diſſolved the diaphragm quite through; ſo that the contents of the ſtomach were found in the cavity of the thorax, and had even affected the lungs in a ſmall degree.

There are very few dead bodies, in which the ſtomach is not, at its great end, in ſome degree digeſted; and one who is acquainted with diſſections, can eaſily trace the gradations from the ſmalleſt to the greateſt.

To be ſenſible of this effect, nothing more is neceſſary, than to compare the inner ſurface of the great end of the ſtomach, with any other part of the inner ſurface; what is ſound, will appear ſoft, ſpongy, and granulated, and without diſtinct blood-veſſels, opake and thick; while the other will appear ſmooth, thin, and more tranſparent; and the veſſels will be ſeen ramifying in its ſubſtance, and upon ſqueezing the blood which they contain from the larger branches to the ſmaller, it will be found to paſs out at the digeſted ends

ends of the veſſels, and appear like drops on the inner ſurface.

Theſe appearances I had often ſeen, and I do ſuppoſe that they had been ſeen by others; but I was at a loſs to account for them; at firſt, I ſuppoſed them to have been produced during life, and was therefore diſpoſed to look upon them as the cauſe of death; but I never found that they had any connection with the ſymptoms: and I was ſtill more at a loſs to account for theſe appearances, when I found that they were moſt frequent in thoſe who died of violent deaths, which made me ſuſpect that the true cauſe was not even imagined (*a*).

At this time I was making many experiments upon digeſtion, on different animals, all of which were killed, at different times, after being fed with different kinds of food;

 ſome

(*a*) The firſt time that I had occaſion to obſerve this appearance in ſuch as died of violence and ſuddenly, and in whom therefore I could not eaſily ſuppoſe it to be the effect of diſeaſe in the living body, was in a man who had his ſkull fractured, and was killed outright by one blow of a poker. Juſt before this accident, he had been in perfect health, and had taken a hearty ſupper of cold meat, cheeſe, bread, and ale. Upon opening the abdomen, I found that the ſtomach, though it ſtill contained a good deal, was diſſolved at its great end, and a conſiderable part of theſe its contents lay looſe in the general cavity of the belly. This appearance puzzled me very

ſome of them were not opened immediately after death, and in ſome of them I found the appearances above deſcribed in the ſtomach. For, purſuing the enquiry about digeſtion, I got the ſtomachs of a vaſt variety of fiſh, which all die of violent deaths, and all may be ſaid to die in perfect health, and with their ſtomach commonly full; in theſe animals we ſee the progreſs of digeſtion moſt diſtinctly; for as they ſwallowed their food whole, that is, without maſtication, and ſwallow fiſh that are much larger than the digeſting part of the ſtomach can contain (the ſhape of the fiſh ſwallowed being very favourable for this enquiry), we find in many inſtances that the part of the ſwallowed fiſh which is lodged in the digeſting part of the ſtomach is more or leſs diſſolved, while that part which remains in the œſophagus is perfectly ſound.

And in many of theſe I found, that this digeſting part of the ſtomach was itſelf re-

very much. The ſecond time was at St. George's Hoſpital, in a man who died a few hours after receiving a blow on his head, which fractured his ſkull likewiſe. From thoſe two caſes, among other conjectures about ſo ſtrange an appearance, I began to ſuſpect that it might be peculiar to caſes of fractured ſkulls; and therefore, whenever I had an opportunity, I examined the ſtomach of every perſon who died of that accident: but I found many of them which had not this appearance. Afterwards I met with it in a ſoldier who had been hanged.

duced

duced to the ſame diſſolved ſtate as the digeſted part of the food.

Being employed upon this ſubject, and therefore enabled to account more readily for appearances which had any connection with it, and obſerving that the half-diſſolved parts of the ſtomach, &c. were ſimilar to the half-digeſted food, it immediately ſtruck me, that it was from the proceſs of digeſtion going on after death, that the ſtomach, being dead, was no longer capable of reſiſting the powers of that menſtruum, which itſelf had formed for the digeſtion of its contents; with this idea, I ſet about making experiments to produce theſe appearances at pleaſure, which would have taught us how long the animal ought to live after feeding, and how long it ſhould remain after death before it is opened; and above all, to find out the method of producing the greateſt digeſtive power in the living ſtomach: but this purſuit led me into an unbounded field.

Theſe appearances throw conſiderable light on the principles of digeſtion; they ſhew that it is not mechanical power, nor contractions of the ſtomach, nor heat, but ſomething ſecreted in the coats of the ſtomach, which is thrown into its cavity, and

there animaliſes the food (*a*), or aſſimilates it to the nature of the blood. The power of this juice is confined or limited to certain ſubſtances, eſpecially of the vegetable and animal kingdoms; and although this menſtruum is capable of acting independently of the ſtomach, yet it is obliged to that viſcus for its continuance.

(*a*) In all the animals, whether carnivorous or not, upon which I made obſervations or experiments to diſcover whether or not there was an acid in the ſtomach, (and I tried this in a great variety), I conſtantly found that there was an acid, but not a ſtrong one, in the juices contained in that viſcus in a natural ſtate.

EXPE-

EXPERIMENTS CONCERNING DIGESTION.

TRANSLATED FROM THE

INAUGURAL DISSERTATION OF DR. STEVENS.

Publiſhed at Edinburgh in 1777.

THE following experiments were made at Edinburgh upon an Huſſar, a man of weak underſtanding, who gained a miſerable livelihood, by ſwallowing ſtones for the amuſement of the common people, at the imminent hazard of his life. He began this practice at the age of ſeven, and has now followed it twenty years. His ſtomach is ſo much diſtended, that he can ſwallow ſeveral ſtones at a time; and theſe may not only be plainly felt, but may be heard, whenever the hypogaſtric region is ſtruck.

EXPERIMENT I.

At eight o'clock in the evening, I gave the ſubject of my experiments a hollow ſilver ſphere, divided into two cavities by a partition, and perforated on the ſurface with a great number of holes, capable of admitting a needle: into one of theſe cavities was put four ſcruples and a half of raw beef, and into the other five ſcruples of raw bleak. The ſphere was voided in twenty-one hours, when the beef was found to have loſt one ſcruple and a half, and the fiſh two ſcruples. The reſt was much ſoftened, but had no diſagreeable ſmell.

II. A few days afterwards he took the ſame ſphere, containing in one cavity a ſcruple and four grains of raw beef, and in the other four ſcruples and eight grains of the ſame boiled. In forty-three hours the ſphere was returned, and the raw fleſh had loſt one ſcruple and two grains, and the boiled one ſcruple and ſixteen grains.

III. Suſpecting that if theſe ſubſtances were divided, ſo that the ſolvent could have freer acceſs to them, more of them would be diſſolved. I procured another ſphere with holes, ſo large as to receive a crow's quill, and encloſed ſome beef a little maſticated in it.

it. It was voided quite empty, thirty-eight hours after it was ſwallowed.

IV. Seeing how readily the chewed meat was diſſolved, I thought of trying whether it would be as ſoon diſſolved in a ſphere with large holes, but without being chewed. I therefore put a ſcruple and eight grains of pork into one cavity, and into the other the ſame quantity of cheeſe. The ſphere was retained forty-three hours, at the end of which not the ſmalleſt remains of either pork or cheeſe could be found.

V. He afterwards ſwallowed the ſame ſphere, containing in one partition ſome roaſted turkey, and in the other ſome boiled ſalt herring. In forty-ſix hours it was voided, and nothing of the turkey or herring now appeared, both having been completely diſſolved.

VI. Having found that animal ſubſtances, though incloſed in tubes, are eaſily concocted, I next determined to try whether vegetables, which are more difficulty digeſted, would be ſo too. I therefore encloſed an equal quantity of raw parſnep and potatoe in a ſphere. It was voided after having continued forty-eight hours in the alimentary canal, when both ſpecies of vegetable were found to be diſſolved.

VII. Pieces

VII. Pieces of apple and turnep, both raw and boiled, were diſſolved in thirty-ſix hours.

VIII. He next ſwallowed ſome grains of wheat, rye, barley, oats, and peaſe, contained in a ſphere, which remained ſeveral hours in the alimentary canal, but no alteration was produced on any of its contents, except upon the peaſe, which were ſwoln, and burſt by the humidity they had imbibed.

IX. The readineſs with which the gaſtric fluid had acted upon roaſted animal ſubſtances, induced me to try what change would be produced by it upon hard ones, ſuch as bone. I therefore incloſed in one partition of a ſphere, ſome of the bone from a leg of mutton, and in the other part of a turkey's wing. The ſphere was retained forty-eight hours. The bone was weighed, and found to have loſt nothing of its weight, while the fleſh, ſkin, and ligaments were quite diſſolved, ſo that the bones of the wing were now quite ſeparate; but they had undergone no perceptible alteration.

X. Inanimate matters being ſo readily ſoluble, I reſolved to enquire how far living animals are capable of reſiſting the action of this powerful menſtruum. With this view, an animal ſuppoſed to be deſtitute of pores, and,

and, according to my experiments, capable of ſuſtaining a degree of heat equal to the human temperature, was encloſed in a ſphere perforated with ſmall holes, to prevent the leech from wounding the ſtomach. The Huſſar took it, and voided it about the uſual time, when nothing was found except a black viſcid miaſma, the remains of the digeſted leech. This experiment was repeated with earth-worms, and they were diſſolved with equal facility. But as they cannot ſo well ſupport the human temperature, it is probable they died before they began to be diſſolved *.

It was my intention to make more experiments of this kind, but as the Huſſar left Edinburgh ſoon afterwards, I was obliged to have recourſe to dogs and ruminating animals.

XI. A whelp, three months old, having been kept fourteen hours without food, was forced to ſwallow four oval ivory globes, of different ſizes, and perforated with many ſmall holes. One contained beef, another haddock, a third potatoe, and a fourth cabbage, all raw, and weighing each ſixteen grains. In four hours the animal was killed and opened. The globes were found in the

* Perhaps this is alſo the caſe with leeches.

ſtomach,

ſtomach, and their reſpective contents were diminiſhed in the following proportions: The fiſh had loſt nine grains, the beef five, the potatoe three, and the cabbage one. The globes themſelves appeared to be thinner, but as I had no ſuſpicion that the ivory would be affected by the gaſtric fluid, I did not weigh them before the experiment. I could not therefore exactly aſcertain their diminution.

XII. Having procured a whelp five months old, it was kept faſting ſixteen hours, and then four of the globes uſed in the foregoing experiment, each containing a certain quantity of mutton, turbot, parſnep, and potatoe were forced upon it. Theſe ſubſtances had been previouſly expoſed to the action of fire, and each weighed ſixteen grains. Seven hours afterwards the animal was killed, and the globes were taken out of the ſtomach; when the fiſh was found to have loſt ten grains and a half, the mutton ſix, the potatoe five, and the parſnep nothing. The ſpheres were become ſtill thinner, but I had as before, neglected to weigh them.

XIII. A dog ſix months old was kept faſting the uſual time, and the ſame four ſpheres were given him. The firſt contained ſixteen grains of boiled mutton, the ſecond as much boiled fiſh, the third the ſame quantity of boiled

boiled potatoe, and the fourth of boiled parſnep. In eight hours it was killed and opened. The globes were found greatly altered. The extreme parts, not the middle, were totally diſſolved, ſo that the contents lay looſe in the ſtomach. The ſpheres, before the experiment, weighed together three ſcruples ſixteen grains; the fragments weighed only one ſcruple and twenty grains. The mutton and fiſh were entirely concocted, the potatoe had loſt twenty-one grains; but the parſnep was unchanged.

XIV. Being ſurprized at the ſpeedy ſolution of ivory by the gaſtric fluid, I determined to ſubject other hard bodies to its action. I therefore carefully weighed three pieces of a ſheep's thigh bone, and gave them to a dog that had been long kept faſting. Seven hours afterwards the animal was killed, and the bones were taken out of the ſtomach. The firſt had loſt ſeven, the ſecond nine, and the third twelve grains. The ſolution began at the internal ſurface, and advanced towards the center, ſo that the cavity was conſiderably augmented (*a*).

I more-

(*a*) In order to aſſure myſelf that this ſolution was not owing to fermentation, or an acid, I immerſed a bone of the ſame kind, in an alimentary mixture, conſiſting of roaſted beef, wheaten

I moreover obliged my dog to ſwallow pieces of cartilage, but I found that the gaſtric fluid produced no effect upon them.

XV. As the ivory ſpheres and bones were ſo readily diſſolved in the foregoing experiments, I was induced to make trial of ſome bodies ſtill harder. With this view I procured ſome cylindrical tin tubes, perforated with a great number of holes; of which four were given to a dog that had been kept faſting twelve hours. The firſt contained ſixteen grains of roaſted beef, the ſecond the ſame quantity of veal, the third of fat, and the fourth of wheaten bread. In ten hours the animal was killed and opened, and the tubes were taken out of its ſtomach. The beef and bread were quite diſſolved; the veal had loſt only ten grains, and the fat eight and a half. The tubes had not undergone the ſmalleſt alteration.

XVI. As in the laſt experiment the veal was not ſo ſoon diſſolved as the beef, I began to ſuſpect that the fleſh of young animals in general is leſs eaſy to digeſt than that of old

wheaten bread and water, beaten into a pulp. When it had remained forty-eight hours in a temperature, equal to 102 deg. of Fahr. Therm. it was examined: the fermentation had run very high, and the acidity was ſtrong, but the bone had undergone no diminution. It was, however, much ſoftened.

ones

ones. I therefore took care to repeat the experiment with lamb and mutton, which were put in equal quantities into two tubes. The reſult was as before. In ſeven hours the mutton was quite diſſolved, whereas the lamb had loſt only ten grains. The remains of veal and lamb in theſe experiments were ſurrounded with a viſcid gelatinous matter.

XVII. Sixteen grains of raw beef, and the ſame quantity of roaſted were incloſed in two tubes, and given to a dog, which was killed ſeven hours afterwards, when the former was found to have loſt fifteen grains, while the latter was completely diſſolved.

XVIII. The ſame experiment was repeated with fiſh inſtead of fleſh. Sixteen grains of raw and as much boiled haddock, were encloſed in two tubes, and given to a dog. When he was killed, no remains of the boiled could be found; the raw portion had loſt fourteen grains.

XIX. I next enquired whether quadrupeds or birds are moſt eaſily digeſted. For this purpoſe, equal quantities of beef, mutton, and fowl were incloſed in three tubes, and given to a dog; they were each roaſted, and weighed ſixteen grains. Upon killing the dog, and examining the tubes, I found that the

the mutton and beef had been diſſolved, while the fowl had only loſt eleven grains.

Moſt of the experiments related above, were repeated oftner than once, and afforded the ſame reſult. We cannot therefore entertain any doubt concerning the mode of digeſtion in this claſs of animals. Whether the concoction of ruminating animals is effected in the ſame manner, I endeavoured to aſcertain by the following experiments.

XX. I gave a ſheep four cylindrical tin tubes, each containing ſixteen grains of raw beef, ſalmon, turnep, or potatoe; ſix hours afterwards the animal was killed; the tubes were found in the firſt ſtomach. The fiſh and fleſh were unaltered, whereas the turnep and potatoe were quite diſſolved.

XXI. The ſame experiment being repeated with the ſame ſubſtances boiled, afforded the ſame reſult. The vegetables were digeſted, and the beef and ſalmon unchanged.

XXII. Having found that the ſheep digeſts vegetables very readily, but is incapable of diſſolving animal ſubſtances, I had next recourſe to the ox. Four tubes, one containing raw beef, another fiſh, a third chopped hay, and the fourth leaves of pot-herbs, were given to an animal of this ſpecies, and it was killed ten hours afterwards. The tubes lay

lay in the firſt ſtomach; the fiſh and fleſh were not altered; but I could find no remains of the hay or herbs.

Many experiments of the ſame kind were made upon this animal, and they led me to the ſame concluſion, viz. that the gaſtric fluid of the ox kind, eaſily and ſpeedily diſſolves vegetables, but is incapable of producing this effect upon animal ſubſtances.

In all theſe experiments, I attribute the ſolution of the food to a powerful menſtruum ſecreted by the coats of the ſtomach. It may be objected, that my experiments do not clearly ſhew whether the food is concocted by the gaſtric fluid, or by fermentation, for both cauſes may act equally upon aliment incloſed in the ſpheres. But beſides the arguments already adduced to ſhew (*a*), that fermentation does not produce this effect, many circumſtances attending theſe experiments clearly ſhew the efficacy of the gaſtric liquor. For in the experiments in which the food was not quite diſſolved, the ſolution always began at the ſurface, and proceeded towards the center, and what remained, ſhewed no tokens of fermentation.

(*a*) In the part that has been omitted.

In the XIIIth experiment ivory was diſſolved, while parſnep, a vegetable of ſoft texture, and liable to fermentation, was not at all altered.

To remove every doubt, the following experiment was ſeveral times repeated, and always afforded the ſame reſult.

XXIII. Having kept a dog faſting eighteen hours, that his ſtomach might be free from the remains of food, I killed it, and collected about half an ounce of pure gaſtric fluid, which was put into a phial with twelve grains of roaſt beef. The ſame quantity of the ſame beef was put into another phial, containing water, in order to ſerve for a term of compariſon. Both phials were placed in a furnace, of which the temperature was equal to 102--104° of Fahrenheit's thermometer. In eight hours the beef in the gaſtric fluid was quite diſſolved, whereas that in the water had undergone no perceptible alteration. In twenty-four hours both phials were taken out of the furnace and carefully examined. The food diſſolved in the gaſtric fluid emitted a rancid and pungent, but by no means a putrid odour; it reſembled very much the ſmell of burnt feathers. The meat in the other phial was quite putrid, and intolerably

tolerably fetid; but its bulk was not diminished.

I carefully obſerved the phial containing the gaſtric fluid during the ſolution, but could perceive no air-bubbles ariſing, or any other token of fermentation. I repeated this experiment with maſticated meat, when the ſolution was much more ſpeedily completed.

I afterwards made trial of mutton, veal, lamb, and other animal, together with a great variety of vegetable ſubſtances; all were eaſily diſſolved; but the time requiſite for the completion of this proceſs was different, and anſwered exactly to the reſults of the preceding experiments.

As in this experiment there was no ſign of fermentation or putrefaction, I ſuſpected that the gaſtric fluid, as well as the ſaliva (*a*), retards both the one and the other. In order to determine this, I made the following experiment.

XXIV. I took two alimentary mixtures, each conſiſting of mutton and bread in equal quantities. Upon one, half an ounce of the recent gaſtric juice of a dog was poured, and

(*a*) Where did the author learn that the ſaliva checks fermentation? It appears from all the experiments that have been made to forward it. T.

upon the other the ſame quantity of pure water. Both mixtures were beaten to a pulp, and incloſed in phials accurately ſtopped; they were then ſet in a furnace, heated to the 102d deg. of Fahrenheit's thermometer. Fermentation took place in a few hours in the phials that contained the water, the ſolid contents roſe to the ſurface, and air was extricated with a conſiderable inteſtine motion. The mixture immerſed in the gaſtric fluid, remained fourteen hours with ſcarce any tokens of fermentation; but a ſhort time afterwards, this proceſs evidently took place. The bread and fleſh aroſe to the ſurface of the mixture, a ſediment began to be depoſited, and air-bubbles were continually extricated. But theſe phænomena continued much longer than in the other phial; the commotion was leſs violent, and the air was not ſo rapidly extricated. When the fermentation had entirely ceaſed, the taſte of the mixture in this phial was indeed acid, but not ſo ſtrong as in the other, and it was converted into a fluid by the ſolvent power of the gaſtric liquor.

XXV. I divided a piece of putrid mutton into two parts, each of which was put into a ſeparate phial, and to one, half an ounce of the recent gaſtric fluid of a dog was added, and

and to the other, which was deſigned as a term of compariſon, as much water. They were ſet in a cool place, and two days afterwards I examined them, when the latter emitted an intolerably putrid ſmell, and the other, though it had yet a bad odour, did not ſmell ſo diſagreeably as the preceding, nor even ſo diſagreeably as at firſt. Upon ſhaking the phial, the meat fell to pieces, but it was not quite diſſolved. This, perhaps, happened, becauſe it was not expoſed to a ſufficient heat.

Theſe experiments throw great light on digeſtion. They ſhew, that it is not the effect of heat, trituration, putrefaction, or fermentation alone, but of a powerful ſolvent, ſecreted by the coats of the ſtomach, which converts the aliment into a fluid, reſembling the blood. If it ſhould be aſked, what defends the organ itſelf, I would anſwer, that it is the vital principle, as Mr. Hunter's (*a*) obſervations ſhew; after death it is diſſolved as readily as any other inanimate ſubſtance. It is probable, that every ſpecies of

(*a*) Philoſoph. Tranſ. for 1772. The ingenious obſerver ſeems, however, to attribute too much to this principle. He ſuppoſes, that whatever poſſeſſes it, is capable of reſiſting the action of the gaſtric liquor; his arguments by no means prove this,

of animal has its peculiar gaſtric liquor, capable of diſſolving certain ſubſtances only. Some living ſolely upon vegetables, others upon animals, and theſe cannot be obliged to feed upon plants, by a faſt of whatever continuance. All, by an infallible inſtinct, chooſe what is beſt adapted to their gaſtric fluid. The food, when diſſolved, is expelled from the ſtomach, and being mixed with the bile and pancreatic juice in the duodenum, is changed into a mild blood and in-

this. Worms, indeed, live in the human ſtomach, but it does not follow, that other animals alſo can, for nature may have given them a particular ſtructure of body. The following conſiderations will render the general propoſition very doubtful. Fiſhes ſwallow and digeſt living crabs, lobſters, &c. The leech is concocted by the human ſtomach, though it has no pores, and can ſuſtain a temperature equal to that of man. Cornelius found a ſnake half digeſted in a bird's ſtomach, but ſtill alive. Plot ſaw one eye conſumed, while the fiſh was alive. It ſeems therefore probable, that the gaſtric liquor acts alſo upon living things. Perhaps, likewiſe, it is ſometimes ſo changed, as to act on the ſtomach itſelf. The following caſes communicated by Dr. Monro render this probable. A lady, that uſed to complain of pain in the ſtomach, died ſuddenly. Upon opening the body, a hole was found in the left ſide, and the coats were relaxed as if they were half putrified. There were no appearances of gangrene. A boy died after having long ſtruggled with ſimilar pains. The ſtomach exhibited the very ſame appearance, if we except the hole. From the preceding ſymptoms, one may venture to ſuppoſe, that ſome alteration was produced before death. But this is only conjecture, and future experiments muſt determine the queſtion.

odorous

odorous liquid, which is denominated chyle. The chyle is abſorbed by numberleſs veſſels, and is carried by the thoracic duct into the ſubclavian vein, in order to repair the conſtant waſte of the body.

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